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EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

CONTENTS.

Some Facts and Thoughts about Light-emitting Animals.
By Professor P. Martin Duncan, M.B. Lond., F.R.S., &c. (Illustrated).

The Birth, Life, and Death of a Storm.
By Robert H. Scott, M.A., F.R.S., &c.

On the Extinct Animals of the Colonies of Great Britain.
By Professor Richard Owen, C.B., F.R.S., &c.

Is Nest-Building an Instinct in Birds?
By Benjamin T. Lowne F.L.S.

The Position of the Silurian, Devonian, and Carboniferous Rocks in the London Area.
By Robert Etheridge, F.R.S., &c. (Illustrated).

REVIEWS.
Electricity—Organic Chemistry—The Gault—Cambridgeshire Geology—The Electric Light—The Heavens—Field Geology—Fragments of Science—The Sea-Shore—British Birds—The Human Species—Trees and Ferns.

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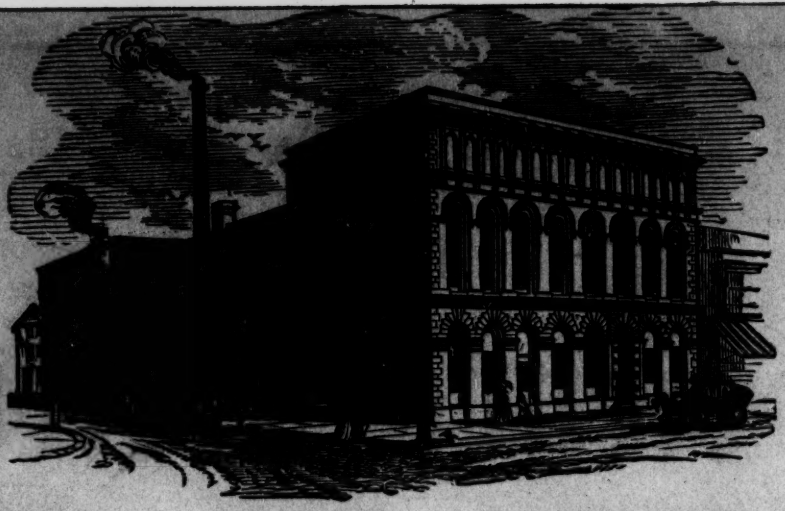

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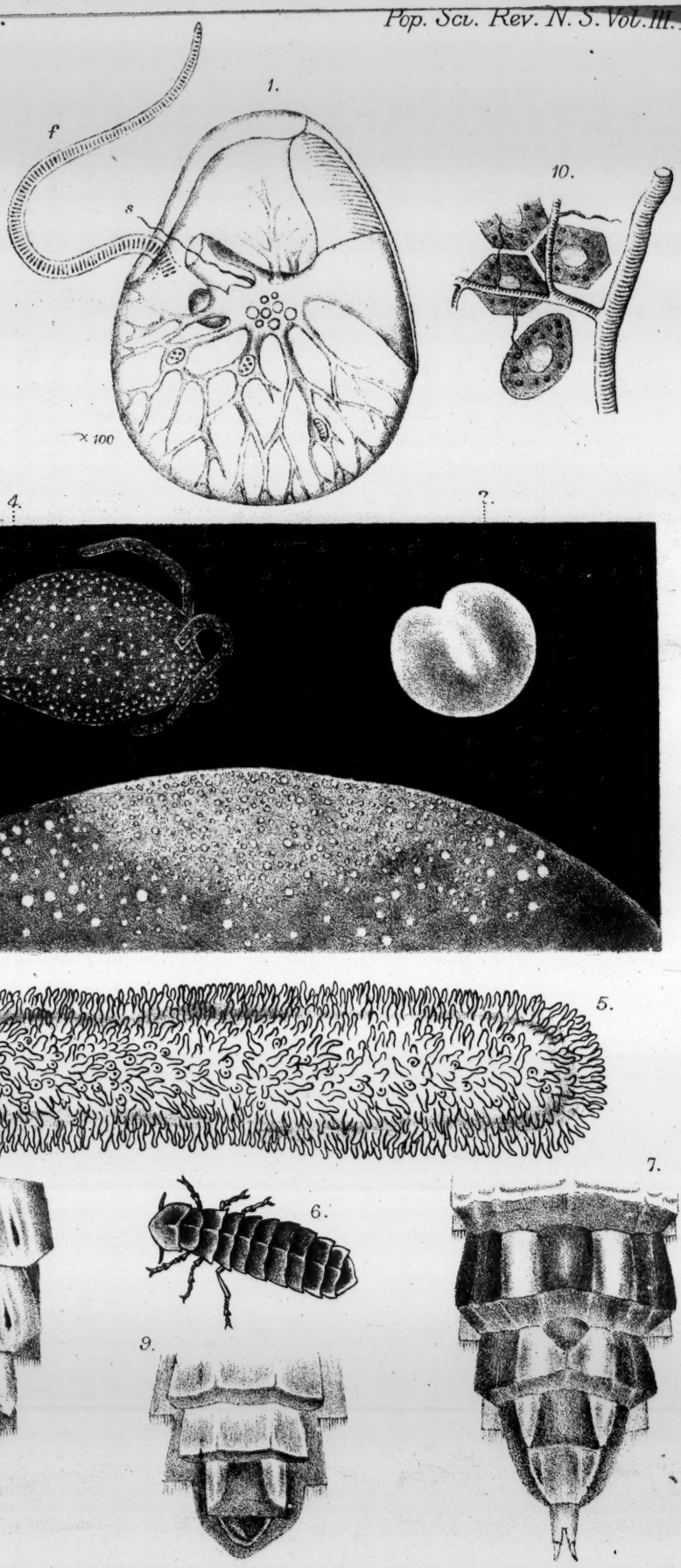

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PHOSPHORESCENT ANIMALS.

SOME FACTS AND THOUGHTS ABOUT LIGHT-EMITTING ANIMALS.

By Professor P. MARTIN DUNCAN, M.B. Lond., F.R.S. &c.

[PLATE VI.]

AFTER the glare of daylight has passed into night, during the warmest months of the year, countless little points of light are often to be seen on the turf and amongst the brake and underwood in the open country of the South of England. The light is distinct enough, and when scattered far and near over a hillside, is always a matter of wonderment to the observer who witnesses the sight for the first time. When curiosity impels anyone to approach the little luminous points more closely, their "phosphorescent" gleam is evident enough, and the greenish white light glows. It increases and diminishes in its intensity, becomes bright and fades in a surrounding mistiness and again flashes out more brilliantly than ever. Hour after hour the green and white illumination persists, but if any one point be carefully watched, it will be observed to cease occasionally for a second or two, and often to move about. Towards the darkest hours the luminous points become more numerous and brilliant; but midnight witnesses the paling of the light which "fadeth at the crowing of the cock."

Searching amongst the grass for the cause of this remarkable light, the hand feels no increase of temperature on approaching the objects which relate to it, and successful seeking discovers a cold, softish insect.

At the same time of the year, when the summer's sun has warmed the surface of the sea, the darkest nights during calm weather off the coasts of our Islands are illuminated by fitful flashes of green, yellow, blue, and rarely red light, which, starting suddenly from one or two spots on the water, spread on all sides in coruscations, or in glowing ripples and increasing breadths, to cease as suddenly as they began. A boat glides into some quiet, dark harbour and sets the sea "aflame;" every dip of the oar produces an extending circlet of light, every drop of spray is luminous, and adds to the sparkling as it falls, and

the moving prow wells out little waves surging with tints of green and gold. Darkness, all the more intense by contrast, succeeds, to be again and again suddenly turned into transient light. In the offing, the sailors say the sea is "briny," and they watch the rippling radiance in their wake, and note the sudden gleams which, commencing at some disturbed spot of the surface, flash out on all sides. At anchor watch, whilst the night is as dark as pitch and the sea is hardly visible, the cable may often look white hot during the intervals of the faint illumination of the surface.

A bucket is lowered, and wood, ropes, hands and arms are alight with liquid heatless fire, and myriads of tiny globes may be seen occasionally in the water, intensely luminous. On going ashore up the wet sands, often enough every footstep is a focus of radiating glimmers, and remains luminous for a while.

These common sights, passed by by most people, are supremely interesting to the thoughtful, and they are the feeble Northern extension of similar phenomena, which are grand indeed in the sub-tropical and torrid regions of the globe, and which, even at some depth in the great oceans, may relieve the eternal darkness. But even on the verge of the sea, Nature's pyrotechny is superb, and Neptune is jealous of Nox, for in the short hour or two between the summer's daylight, spray, waves, and all they wash, are often intensely, long or momentarily, bright.

The dredge brings up, out of comparatively shallow water, Actinozoa, which, hitherto buried up to their tentacular ring, are light-emitting. A diver sees a luminous spot on the submerged limestone rock he is examining, and finds a boring shell smeared with luminosity. The weary sailor, tired with the monotony and the great heat of the tropical day, peering into the depths near the coral banks of North Australia and New Caledonia, sees long tracks of wandering light, and wonders at the graceful evolutions and fierce attacks of the sea-snakes, lit up as they are with a fiery path. Or, dreamily watching, he marvels at the radiant course of the predaceous fish as they rise to the surface and rush beneath, after their prey. Some whalers, when the ship is hove to and gently rolling in the dark nights of the Southern Ocean, see the mighty monsters shoot up above the gleaming surface amidst a fountain of lurid phosphorescent spray, and fall splashing again and again in ponderous play, as if they loved to show their strength amidst showers and waves of light. Sights such as these are not the invariable accompaniment of the darkness far away in Northern seas; for there the spreading phosphorescence of the surface often pales with the rising moon, or the display of the Aurora. But even then, mid-ocean becomes luminous as the tide carries the host of Medusæ along. Even when the moon is at its full, and the sea is bright with its lustre,

there is a world of light, deep down below the surface. Great domes of pale gold with long streamers, move slowly along in endless succession; small silvery discs swim, now enlarging and now contracting; and here and there a green or bluish gleam marks the course of a tiny but rapidly rising and sinking globe. Hour after hour the procession passes by; and the fishermen hauling in their nets from the midst, drag out liquid light, and the soft sea-jellies, crushed and torn piecemeal, shine in every clinging particle. The night grows dark, the wind rises and is cold, and the tide changes, so does the luminosity of the sea. The pale spectres below the surface sink deeper, and are lost to sight; but the increasing waves are tinged here and there with green and white; and often along a line, where the fresh water is mixing with the salt in the estuary, there is a brightness so intense that boats and shores are visible. But if such sights are to be seen on the surface, what must not be the phosphorescence of the depths? Every Sea-pen is glorious in its light; in fact, nearly every eight-armed Alcyonian is thus resplendent; and the social *Pyrosoma*, bulky and a free swimmer, glows like a bar of hot metal, with a white and green radiance.

Just as in some places in England, the points of light on the turf may be seen, simultaneously, with the luminosity of the surface of the sea close by, so in the tropics, active and flying specks of brightness compete on shore with the diffused splendour off the coast. All this light, so vast in its world-wide amount, is heatless. Crowd it all together, and a vast city might be illuminated without raising the thermometer probably many degrees, if at all; and all this vibration, this consequence of intensely rapid molecular motion, is the result of the energy of life.

The points of light on the turf of the South of England are produced by a beetle—the "glowworm," *Lampyris*; and the genus is world-wide in its distribution. The fire-flies of the tropics are principally Elater beetles, and others allied to them in classification; and there are Hemiptera as well as Myriopoda which add to the list. Our sea-surface illumination is due to myriads of *Noctiluca miliaris*, and the same and other species of the genus are world-wide. The minuter Crustacea, the Alcyonarians, Medusæ, Polyzoa, Ophiurans, Tunicata, Annelida, and Mollusca, add species to the luminous assemblage; and probably more than one hundred and fifty genera, most of which have numerous species which are prolific in individuals, are luminous under certain circumstances. It is possible that some fish noticed by Dr. Günther are phosphorescent in the deep sea.

The intensity and the colour of the light emitted, differ with the genus, species, locality, and season, and certain species have a definite and peculiar light. The English glowworm has

a misty-coloured light, which is usually greenish; that of Italy is brilliantly blue; whilst the Australian species emits a pulsating light. The fire-fly of the West Indies glows with a very white light; but it is doubtful if the *Fulgora*, so often seen in books as the Lantern fly, has a scarlet light, or any at all. The rapid coruscating flashes on the sea and on the sands, are now and then yellow or white, but rarely scarlet, or reddish, and are produced by crustaceans. Other insects in the tropics give out a deep blue and white light; and the Pacific Islands hundred-legs produce a brilliant emerald green. *Noctiluca* gives out a greenish and often bluish light, and the Medusoids vivid yellow, gold, green, blue and white tints. The Sea-pens give out white as well as coloured light; and that of the Echinoderms is green. The green and white tints are the commonest colours, yellow is rare, and so are the reds and blues, whilst purples are unusual. The Gorgonoids give out a beautiful lilac.

A very slight examination of the animals connected with these luminous phenomena, indicates that they are produced in different manners. For instance, *Noctiluca*, *Pholas*, and *Lampyris*, are readily anatomized, and the source of the luminosity is found to differ in each. Hence it is important to consider some typical cases which illustrate the varieties of light-production.

Consider, first of all, *Noctiluca miliaris* (Pl. VI. figs. 1–3), which is very common in the warm summer months all round the English coast and up the Humber and Bristol Channel. It is impossible to estimate the countless numbers of this minute, peach-shaped, flagellate infusorian in some parts of our seas. For instance, on the Essex coast some years since, I found every tumbler of sea-water taken out between the Gunfleet sands and the mainland, crowded with them; and most of the actively-moving, little gelatinous transparent things were larger than their standard of $\frac{1}{80}$th inch in diameter. They move by means of a filiform tentacle, of the length of the diameter of the body, and about $\frac{1}{1800}$th inch in its breadth, which is placed close to the opening of the so-called mouth. The tentacle is long and flat and has striations across it, but which appear to be beneath the delicate cuticle. A long, delicate, undulating fibril comes from the bottom of the oral cavity, and can be protruded and withdrawn, and close to it is a horny-looking, tooth-like body, $\frac{1}{7000}$th inch high. The opening into the interior, or mouth, is the extremity of a funnel, which ends within, in the minutely-granular substance forming the bulk of the body, and which, if it were perfectly transparent and uniform, no part being differentiated, might be called protoplasm. This granular sarcode has spaces in it containing water, or vacuoles, one often being large, but they do not contract and enlarge like those of many Protozoa. Radiating in meshes, which are coarse near the

mouth and very minute and fibrillar near the outside, is a denser sarcode, and there are granules on the fibrils. These fibrillar meshes are enveloped in a minutely-granular sarcode, and they reach to just under the surface of the animal, ending in a clear protoplasmic layer, which underlies the equally clear and transparent cuticle or cell-wall. Near the vacuolated part is a small nucleus, and it is evidently in relation with the fibrillar radiations; and there are occasionally nucleated cell-like bodies in the peripheral layer of protoplasm. As these are probably spores, it is not necessary to consider them. Now there is movement in the striated tentacle and in the long filamentous cilium, and there is amœboid streaming of granules on the radiating fibrils, but no change of general shape constantly occurs. The animal respires by its outer cell-wall, grows in size by additions to the finer granular parts, and the principal seat of this activity must be just beneath the cell-wall.

Now, on watching *Noctiluca* in captivity, one is struck by the very vivid light which it emits. It is a sudden flash, lasting but for a short time, and is repeated over and over again, some intermission being apparently inevitable and necessary. The light is greenish, and is produced not especially near the seat of tentacular and fibrillar movement, but just under the cell-wall. It arises from scores of minute, independent points, which scintillate and illuminate the rest: in fact, where respiration and assimilation are at their greatest, where the vital energy is in full action. Anything which increases this activity produces increase of the light, and the converse is true. Pure, highly aërated sea-water, changed over and over again, adds to its brilliancy and persistence. Oxygen forced into the water produces more light, and the stimulation of fresh (non-saline) water at first does the same, but sooner or later it is destructive to the animal. Physical stimulation evidently acts on the light, and produces it for a time, and a *constant illumination* precedes death, when light ceases. The light diminishes *in vacuo*, and under the influence of carbonic acid gas.

Quatrefages experimented upon *Noctiluca*, and added alcohol; and this produced a definite continuous luminous ring, and then a general peripheral illumination, which lasted for a while and until death. Finally, it is well known that nets which have been dragged out of a sea crowded with *Noctiluca*, retain light-emitting powers until the meshes become dry. The sun-light has nothing to do with the luminosity of *Noctiluca*.

The Spongidæ have not as yet been recorded as having luminous kinds, but the Hydrozoa teem with them; and moreover the gift, so common in the planoblasts, is found in some species in the stationary and vegetative animal. Probably nearly all Medusæ are luminous, and notably the larger *Aureliæ*

and *Zygodactylæ*, whose light is decided, although like a dim halo sometimes, but grandly golden at others, and especially when the creatures are broken by hauling in. Agassiz noticed that the blue tint of the seeming phosphorescence, was often due to a Medusa, *Dysmorphosa fulgurans*, which breeds others from its proboscis, and thus readily adds to its vast numbers. On the other hand, the stem or trophosome, out of which *Obelia* is developed, has a pulsating light running up it, whilst the free-swimming disc is said to be non-luminous. The globular jelly-fish with paddles, or the Ctenophora, so active in the sea, are brilliantly luminous, and it appears that many of the horny Sertularians give out light. The luminous part of the Medusæ is superficial when they are swimming and entire, and it appears to be restricted to the upper part of the umbrella, to the margin of the disc, and to the tentacles. But extreme irritation and tearing will develop light apparently everywhere, and the slippery semi-solid sarcode clings to everything, and is for a while luminous. It does not appear that the natural luminosity is greater underneath, where Schäfer has noticed radiating nerve-fibres, than on the top, where there is a delicate epithelium, whose flat cells contain minute points of fatty matter, and where no nerves have been found. The tentacles get luminous, and they are without any evidence of nerve, except perhaps where they start from the margin of the umbrella or disc. There is often much defined light at the so-called eye-spots at the edge of the disc, and it may be in relation to the epithelium there, related as this is to nerve. In the mass of the animal there is no highly differentiated protoplasm, but there is much of a low character, and it is all this that is so golden and white, when rupture has taken place. It is hard to believe that the nerves and fatty matters have anything to do with the luminous phenomena here, and certainly they have not in the trophosome of *Obelia*. Protoplasm, in a state of active nutrition, appears to be the seat of the movement which produces the light-wave.

It must be remarked that the great jelly-fish of our coasts and of other seas are not luminous during the whole of their summer life, for they may be seen crowding many estuaries in the hot months, as the twilight merges into night, and not a sparkle of light is visible amongst them.

Phosphorescence does not appear to have been noticed in the reef-building corals, nor in those solitary ones which can be kept in aquaria, but some of the Actinidæ, or sea-anemones, are brilliantly luminous. One notable example is the mud-loving, free, long-bodied *Iluanthos scoticus*, which leaves its rayed disc just above the surface of the ooze, shining like a star here and there, and retaining its light when brought up with the dredge. The extraordinary luminosity of vast numbers of

the Alcyonarian Pennatulidæ and Gorgonidæ compensates for the comparative absence of the phenomena in the other members of their group. Even in the cold North Sea, the Sea-pens, and their long-stalked, short-polyped allies, the *Virgulariæ*, add to the sea light, and the *Gorgoniæ* do the same. They are resplendent in the Mediterranean; and Moseley states that all the Alcyonarians dredged up by the *Challenger* from deep water were found to be brilliantly light-emitting, and that their phosphorescence agreed in its manner of exhibition with that observed in shallow-water forms. He examined the light emitted by three species of deep-sea Alcyonaria with the spectroscope, and found it to consist of the red, yellow, and green rays only.

Panceri notices the light of *Pennatula phosphorea*, which is an eight-tentacled Alcyonarian, with a stem with pinnate branches, carrying zooids or polypes. The long stem reaching below the branches consists of canal tubes, which are in communication with the polypes through the branches; and it is covered with sarcode that is comparatively rudimentary, and which is liable to become infiltrated with water, or to be hydropic, when brought up from the deep sea. The polypes, when fully expanded, are in rows on the upper surface of the branches, and each has eight pinnate tentacles, and at their base a slight swelling on the outside. From each of these eight swellings an opaque white cord passes down the outside of the visceral cavity of each polype to the sarcode of the branch.

These cords are canals in the sarcode, and when they are compressed, their contents may pass either into the hollow of each tentacle, or backwards into the tubular cavities of the branchlets and stem, and very little force suffices to burst them. When examined under the microscope, the contents are found to be cells and a fluid, and the opacity and white colour are produced by the cell contents, which consist of minute highly refracting globular particles, having, chemically and optically, all the properties of fatty matter. This substance is remarkable for its persistence without undergoing decomposition long after the death of the polype. In the substance of the cords there are cells which are stellate in shape, with prolongations, and resembling multipolar ganglion nerve cells; and others are simple enlargements along the course of a fibre. Besides these there are many albuminoid granules and some white particles of a mineral nature, but which does not consist of carbonate or phosphate of lime.

Now this Sea-pen is luminous universally, when seen under favourable circumstances in the open sea, and it has its hours of darkness. When caught to be experimented upon, the animal lights up in a very remarkable and definite manner. Should the long supporting axial stem be pinched, the polypes

nearest the stem on the lowest branchlets, become sparklingly luminous one after the other, and, when they are all illuminated, those of the next branchlets begin to shine, until in succession the whole are glowing. A slight interval of time, amounting to $\frac{4}{5}$ second, occurs between the stimulation and the appearance of the light, and the Sea-pen $6\frac{1}{10}$ inches long was illuminated in $2\frac{1}{5}$ seconds.

On pinching the top of a Sea-pen of this species, the lighting up commenced in the nearest polypes, and then those of the next lowest branchlets took up the effect, and the phenomena of the previous experiment, were simply reversed.

Again, on irritating one of the polypes at the end of a branchlet, its luminosity went to its neighbour, and then all followed one after the other; and if those at the beginning and ending of a branchlet were touched, the lighting up was towards those in and between them.

This successional illumination is very decided, and, when it is completed, the light is pretty constant. But it is evident that on irritating one of the polypes it "takes fire," as it were, at the edge of the tentacular apparatus, some luminosity remaining on the implement and in the intermediate water.

These remarks, the results of Panceri's interesting studies, may recall to mind the early experiment of Spallanzani, who, on compressing the stem of a *Pennatula*, obtained a light from the other extremity, and the fact that crushing the stem and a few branchlets, produces a *substance* which becomes diffused and lights up everything to which it adheres.

Careful observation has determined that when the pen is perfect, the light is emitted from the eight opaque cords of each polype, and that it can commence and continue without their rupture. On the other hand, rupture of a cord excites the luminosity of the whole, and the escaping fatty matter is luminous after its separation and after the death of the animal.

There is no sensible increase of temperature, and the tint of the monochromatic light is azure or greenish, but never red. In this beautiful instance of this remarkable vital luminousness there is evidently a photogenic structure and an elaborated organic material capable of producing light after removal from the animal. The sequence of illuminating is slow in the whole pen, and only at the rate of a yard in 20 seconds—a rate far less than that of the movement of nerve force. Yet the presence of the lowly-organised nervous element indicates that the regulating of the light may relate to it as its function. Clearly the phosphoresence of the Pennatulid is in advance of that of the simpler protoplasmic movement of the Protozoa and of the slime of the Actinoid. Sir Wyville Thomson notices the coming up, in a trawl let down to a depth of 2,125 fathoms of a magnificent "clustered

sea polype" (*Umbellularia grœnlandica*), consisting of "twelve gigantic Alcyonarian polypes, each with eight fringed arms, terminating in a close cluster on a calcareous stem ninety centimetres high." He states that when this splendid Pennatulid was taken from the trawl, the polypes and the membrane covering the hard axis of the stem were so brightly phosphorescent that Captain Maclear found it easy to determine the character of the light by the spectroscope. It gave a very restrictedly-continuous spectrum, sharply included between the lines *b* and D.* The same naturalist writes, after dredging in 828 fathoms off St. Vincent, that the trawl "seemed to have gone over a regular field of a delicate simple Gorgonoid, with a thin wire-like axis slightly twisted spirally, a small tuft of irregular rootlets at the base, and long exsert polypes. The stems, which were from 18 inches to 2 feet in length, were coiled in great hanks round the trawl beam and entangled in masses in the net, and as they showed a most vivid phosphorescence of a pale lilac colour, their immense numbers suggested a wonderful state of things beneath —animated corn-fields waving gently in the slow tidal current, and glowing with soft diffused light, scintillating and sparkling on the slightest touch, and now and again breaking into long avenues of vivid light indicating the paths of fishes or other wandering denizens of their enchanted region." †

Again, in the "Voyage of the Porcupine" ‡ the same fortunate naturalist noticed the Sea-pen, *Pavonia quadrangularis*, which entangled the dredge with its pink stems a metre long, fringed with hundreds of polypes, to be "resplendent with a pale lilac phosphorescence like the flame of cyanogen gas, almost constant, sometimes flashing out at one point more brightly, and then dying gradually into comparative dimness, but always sufficiently bright to make every portion of a stem caught in the tangles or sticking to the ropes distinctly visible."

Probably the grandest display of light-emitting is by the great cylindrical-looking *Pyrosoma*, one of the Tunicata (Pl. VI. fig. 5). This animal is really a compound one, and the common uniting tissue has the shape of a hollow cylinder rounded and closed at one end and cut short and open at the other. This is firm and transparent, like so much cartilage, and on its outside are arranged numerous whorls of separate zooids. Each zooid projecting is large near the supporting cylinder and smaller where free, and this end has the mouth opening, whilst the base is perforated by holes, which are continued through the cylinder. The water system thus opens into the hollow cylinder, and the water issuing

* "The Atlantic," vol. i. "The Voyage of the Challenger," p. 151. That is, in the green, near the less refrangible part.

† Thomson, *Op. cit.* p. 119.

‡ Thomson, "Cruise of the Porcupine," p. 149.

from it propels the whole in the opposite direction, at the same time that it revolves on its long axis. In the Mediterranean the Pyrosomes are from two to fourteen inches in length, and they may be three inches in diameter; they are seen in great companies, and when floating and revolving just below the surface, look like incandescent rods of iron. The light is said to be polychroic in the Pyrosome of the Atlantic, or of a vivid green; and it is azure in a gigantic species. It does not come, according to Panceri, from every spot on the body, but from two round spots, one on either side of each of the zooids, situated over the position of the ganglia of the nervous system, and there are loops like cords passing over the narrow end connecting them (figs. 1 and 2). They are placed between the two tunics of the integument, and are attached to the outer one. After a while the light becomes diffused over the whole surface. Panceri states that when the animal is not over-stimulated, the light is intermittent, and that it consists of sparks from the special cells in each zooid. The luminous bodies are photogenic structures, and produce an albuminoid substance, and also much that is soluble in ether. This matter may become diffused by handling, and retains its luminosity for some time. Panceri states that the light is increased by, and lasts long in fresh water. The largest kind of this wonderful light-emitting compound Tunicate is a grand sight in the night, as it gives out suddenly a vivid greenish light, large in its dimensions, and then it sinks to the depths. Moseley writes: "A giant Pyrosoma was caught by me in the deep-sea trawl. It was like a great sac, with its walls of jelly about an inch in thickness. It was four feet in length and ten inches in diameter. When a Pyrosoma is stimulated by having its surface touched, the phosphorescent light breaks out at first at the spot stimulated, and then spreads

Fig. 1. The open end of *Pyrosoma giganteum*, showing the zooids with their luminous spots.
Fig. 2. The outer end of a single zooid, with luminous spots, enlarged.

over the surface of the colony as the stimulation is transmitted to the surrounding animals. I wrote my name with my finger on the great Pyrosome as it lay on deck in a tub at night, and my name came out in a few seconds in letters of fire."* Sir Wyville Thomson, noticing the "blaze of phosphorescence" off the Cape Verd Islands, states that the track of the ship was an avenue of intense brightness. "It was easy to read the smallest print sitting at the after-port in my cabin, and the bows shed on either side rapidly widening wedges of radiance, so vivid as to throw the sails and rigging into distinct lights and shadows. The first night or two after leaving San Iago the phosphorescence seemed to be chiefly due to a large Pyrosoma, of which we took many specimens in the tow-net, and which glowed in the water with a white light like that from molten iron."†

All luminous animals are not illuminators of the surface water or deep sea, for some shine where their gift is not appreciated by others. The burrowing shell-fish, *Pholas dactylus*, lives hidden up; but is nevertheless provided with photogenic structures and substances, and these are also nearly hidden in the enveloping tissues of the bivalve. The elongated cylindrical shells are well-known objects in most cabinets, and it is only necessary to state that the animal has a large foot, and that the combined siphons are large, cylindrical, and furnished with fringed orifices. Now, the photogenic structures are two parallel cords, containing opaque white matter running down the anterior siphon, and two small triangular spots at the entrance of it, and, lastly, an arched cord corresponding with the superior edge of the mantle, reaching to the middle near the valves. The cords and spots are convoluted lobes of the mucous membrane. The cords stand out in relief, and their white colour distinguishes them, and although they are only elevations of the subcuticular tissue, they contain special cells, or rather epithelium, which produces the phosphorescent matter. The whole surface of the *Pholas* is covered with ciliated epithelium, which dips down into all the parts of the animal; but the special epithelium differs from this. It is nucleated and crammed with granules, and the cells are very refractive. The cells are very fragile, and allow their contents, i.e. granular nuclei and refractive granules, to escape readily. These are soluble in ether and alcohol. Under ordinary circumstances this photogenic apparatus is hidden; but violence readily displaces the special cells, which burst, and their contents are carried all over the surface by the water, assisted by the general ciliation. The white substance, fat-like, retains its luminosity when spread out on paper for hours, but the light does not appear to be accom-

* Moseley, "Notes of a Naturalist on the Challenger."

† "Voyage of the Challenger," ii. p. 85.

panied by an evolution of heat. When it is placed in carbonic acid gas, the light pales and ceases. On the other hand, the photogenic substance, when barely luminous, is rendered so by physical contact. Agitation, and the addition of fresh or salt water, develop the light, and the same effect is produced by electricity and by heat. The light is monochromatic, and has a constant place in the spectrum as an azure band from E to F, that is to say, in the green, but in the more refrangible part.

The luminosity of one of the sea-slugs of the Mediterranean and Pacific is as remarkable as the creature producing it. Living a pelagic life, swimming freely with a fan-like vertical tail, this little transparent *Phyllirhoë bucephala* (Pl. VI. fig. 4) has no shell when in the adult stage, neither has it a foot, but its body is compressed and fish-shaped, and it has a round and truncated muzzle, behind which are two long flexible tentacles. It has no branchiæ, and respiration appears to go on through the general surface. Now to add to the beauty of this translucent creature, light-emission from many distinct round spots renders the tissues transparent and luminous. And when it is swimming vigorously, the whole surface shines with a diffused light. The sexes are combined in this delicate slug, which must be a nice morsel for many a fish, and which must find its phosphorescence a fatal gift. There does not appear, however, to be any special photogenic substance. The light comes from globular cells with an envelope terminating in the outer coat of a nerve. The cells are nucleated, and at first sight resemble Pacinian bodies without their internal structure. They nevertheless are terminations of nerves just under the cuticle. (Fig. 4*a*).

Some Ophiurans are brilliantly phosphorescent, and it may be said from our present knowledge, that those which live at considerable depths are more so than the shallow-water forms. Their luminosity has no reference to the temperature of the surface-water; and such a species as *Ophiacantha spinulosa*, which has a great bathymetrical range, is intensely brilliant when dredged out of very cold water. Sir Wyville Thomson has given a very interesting description of the phenomena in "The Cruise of the Porcupine." He writes: "Some of these hauls were taken late in the evening, and the tangles were spangled over with stars of the most brilliant uranian green; little stars, for the phosphorescent light was much more vivid in the younger and smaller individuals. The light was not constant nor continuous all over the star; but sometimes it struck out a line of fire all round the disc, flashing, or, one might rather say, glowing up to the centre: then that would fade, and a defined patch, a centimetre or so long, break out in the middle of an arm and travel slowly out to the point, or the whole five rays would light up at the ends and spread the fire inwards. Very young

Ophiacanthæ, only lately rid of their '*plutei*,' shone very brightly."

The position of the luminosity is removed from the nervous cords, and in decalcified specimens I have failed to trace nervous filaments on the top of the disc and in the substance, or near the upper arm-plates of the rays. But in a specimen from the Icy sea of North Smith's Sound, collected during Sir George Nares' expedition, and sent to me for description, I traced a filmy mucous covering here and there, which seemed to be an exaggeration of the excessively thin epiderm which evidently, in the young forms, covers the plates and the bases of the spines. The disc is covered with a crowd of minute spicular projections, each terminating in a bunch of small thorny knobs, or in three, four, or more rather sharp spicules. These delicate appendages are developed within the skin, as are also the granular elements which constitute the plates of the arms. It is possible that the luminous property resides in this delicate epiderm; and the probability is increased when it is noticed that the phenomenon is most decided in young individuals. It may be possible, however, that the Ophiuran has no photogenic structures, and that the light is the product of foreign animal substances which have become entangled by it as it moved over the mud of the sea floor on which it feeds.

Many years since, Quatrefages, in a very exhaustive memoir on the phosphorescence of marine animals,* attributed the light of the Ophiuran he examined to muscular contraction, and he found it arising between the plates of the arms. He did not see any luminous condition of the disc. But that this occurs is undoubted, and there are no muscular fibres there.

A considerable number of Crustacea are luminous under certain conditions, and the light-emission is sufficiently remarkable. In very transparent ten-footed kinds, and indeed in the small Entomostraca, as well as in many of the Sand-hopper group, a vivid short-lived light is emitted. Its colour is often redder than that of any other animals, and it is localized at first, for it starts from the junction of the legs with the body, and extends rapidly beneath the skin; and then it becomes diffused, the whole body glowing for a while. Some of the host of marine worms are luminous occasionally, and especially some of the genus *Nereis* and of the tube-making *Chætopterus*.

They emit a greenish light, and Quatrefages noticed that the phenomenon consists of a quick series of scintillations, which pass along several segments of the body, lasting but an instant. The flashes can be produced by irritating the worm, and they appear to accompany muscular contraction. Finally, as regards

* See the literature of the subject at the end of my article "Photogenic Structures"—"Micrographic Dictionary," third edition.

marine animal luminosity, the Cuttles and Squids are slightly light-emitting on their outer surface.

I am not aware of any fresh-water invertebrate which possesses the gift, and the statement that Infusoria are occasionally luminous does not appear to be founded on satisfactory evidence.

On land, certain Myriopoda give out a sparkling light, resulting from muscular contraction; and there is a remarkable slug found in Teneriffe, *Limax* or *Phosphorax noctilucus*, which has a luminous pore in the posterior border of the mantle. Many insects have little tiny spots on them which emit light, and it would appear that the localization of the minute phenomenon is in relation with wax glands. On the other hand, the great-headed Fulgora or lantern-fly is said by some naturalists to glow with red and white all about the forepart, and by other observers to do nothing of the kind.

The great display is produced by some species of two families of beetles, the *Lampyridæ* and *Elateridæ*, and the glowworm is one of the former. Belonging to the genus *Lampyris*, it is in classification, in the neighbourhood of the family *Telephoridæ*, and its close ally is the genus *Drilus*, in which great disparity between the sexes is not accompanied by luminous phenomena. *Lampyris* and *Drilus* lead the same kind of lives, and in the larval state are carnivorous, preying on snails, whose body they devour during life. As every work on Entomology has descriptions of species of *Lampyris*, it is only necessary to group the gifts of all, in the following remarks. The large yellow egg is even luminous on first leaving the body of the female. It is stuck on to moss, low grass, or even earth by a viscid fluid; and when it is hatched the long-narrow flat larva soon begins its cruel life, and has an apparatus for brushing off the slime of its victim. It attains its full size in warm Aprils, and some turn to the pupa condition in the summer; but usually the larva lives on, hybernates in the winter, and turns to the pupa in the spring. The larva has photogenic organs on the antepenultimate segment of the body (Pl. VI. fig. 9); they are on its under surface, one on each side of the middle line, and are like small sacs in shape. Overlapped more or less by the segment in front, they become visible when the insect extends its abdomen, and then they are noticed to be luminous. On the other hand, when the body is retracted they are hidden, and the light is not seen. Under all circumstances the light is excessively feeble.

When about to undergo the first metamorphosis, this larva becomes quiescent, and after skin-shedding, a pupa is presented—not a quiet one, however, for it has the power of moving the antennæ, head, and legs, and of twisting its body about and pushing itself along by the alternate contraction and expansion of the abdomen. The female pupa is without wings, but the

male has them, and the elytra, in a rudimentary condition. Both are slightly luminous. The last metamorphosis develops the perfect males and females, the last being apterous, the former being able to fly. Both, and not only the females, as has been popularly believed, are light-emitting, but the lady has greatly the advantage in brilliancy and in the extent of her photogenic apparatus. In her (fig. 7) they consist of six separate thin sacs of a white colour, each one occupying most of the width of the underside of a segment of the body. They are situate immediately beneath the skin of the ventral surface of the three segments which precede the last but one; and in the male they are on the penultimate and antepenultimate segments only (fig. 8). In the female the sacs on the fourth and fifth segments from the end are rectangular and large and the others are smaller. A thin expanse of the common soft integument covers them, and they are in contact with the last two nervous ganglia, many large air-tubes, and, in the female, with the sexual organs. They are exposed and hidden by the expansion and contraction of the abdomen, and their light is visible under the first condition; but when in full vigour, the luminous appearance may diminish, but not be quite lost under the second. This has something to do with the glowing. In all the grades of development the sacs are more worthy of the name of layers or laminæ, and they consist of a mass of large cells with nuclei, and refractive granules. These are aggregated without order, in the larva, and covered with an investing tissue, in which tracheæ (air-tubes) and minute nerves ramify, the tracheæ entering within and coming in contact with the cells joining on to their walls (fig. 10). In the female, the lamina is made up of a number of these cell-aggregates or organs, and there is a yellowish tinge in the part nearest the outer skin, and the back part is crowded with the refractive granules, and has a white and opaque tint. It is said, and one would like it more satisfactorily proved, that the refractive granules contain uric acid; and, on the other hand, it is by no means certain that the whole is not closely allied to that very recondite and unstable organic compound, wax.

Many entomologists are disposed to connect these highly fatty, light-emitting organs, so well provided with air-tubes and nerves, and so close to those organs where the most rapid structural changes progress in some periods of insect life, with the great mass of body and inter-muscle fat. This fat, however, diminishes with the advance of the sexual organs, and we know that in some insects a positive development of immature young takes place in it; but the luminous organ is present in the larva, and is most developed in the perfect state. Hence more knowledge is required before these views can receive universal acknowledgment.

The sacs continue to shine, for a while, after removal from the body, and the epithelium-looking cells retain their luminosity, when smeared over a moist surface for a time, but drying destroys the power. Oil and water do not affect the sacs; acids and alkalies arrest the light, and glycerine also, but the light returns on washing it off. The glow becomes extinct *in vacuo*, but returns on the admission of air.

Mr. Darwin writes, "All the fire-flies which I caught here (at Rio), belonged to the Lampyridæ (in which family the English glowworm is included), and the greater number of specimens were of *Lampyris occidentalis*. I found that this insect emitted the most brilliant flashes when irritated; in the intervals the abdominal rings were obscured. The flash was almost co-instantaneous in the two rings, but it was just perceptible first in the anterior one. The shining matter was fluid and very adhesive; little spots, where the skin has been torn, continued bright with a slight scintillation, whilst the uninjured parts were obscured. When the insect was decapitated the rings remained uninterruptedly bright, but not so brilliant as before. Local irritation with a needle always increased the vividness of the light. The rings in one instance retained their luminous property nearly twenty-four hours after the death of the insect. From these facts it would appear probable that the animal has only the power of concealing or extinguishing the light for short intervals, and that at other times the display is involuntary. On the muddy and wet gravel walks I found the larvæ of this *Lampyris* in great numbers. They resembled in general form the female of the English glowworm. These larvæ possessed but feeble luminous powers; and on the slightest touch they feigned death, and ceased to shine, nor did irritation excite any fresh display."

The Elater tribe furnish the commonest "fire-flies" of the tropics, and the light comes from a spot on either side of the front part of the body, where there is a yellow oval mass of cell-aggregates and tracheæ.

There is great scope for thought and speculation about all these facts, and it is evident that we do not yet know enough of the anatomy and physiology of the photogenic organs of many animals. But with our present knowledge it is possible to obtain some tolerably definite ideas on the subject of animal luminousness. Firstly, the spectroscope gives no satisfactory assistance. It tells us that the light is not produced by a gas, and still that there is something unusual about it, for the green part of the spectrum, in which it is found, glows as it were, in the least refrangible part, or may be said to be more intense near the red than in the other part of the green. That the term phosphorescence is of no scientific value is evident; it only relates to the

similarity of the glow of the *Lampyris*, and the light accompanying the oxidation of phosphorus, and there is not enough (if there be any) of the element in these tiny things to account for the special phenomena.

Fungi, decaying fish, and the flesh of lobsters are luminous under certain conditions, but the phenomena differ from those of the living animal, and are no more to be satisfactorily compared, than they are with the sharp emanation of light on the crystallization of tartar emetic, or with the results of the mixture of hydrochloric acid and arsenic during its crystallization.

It is evident that in some animals there is no special photogenic structure; that in others it is present as highly refractive cell contents; and in the Insecta there are aggregations of these cells into special organs, which are supplied with air-tubes, nerves, and blood. It is equally clear that whilst in the first and second groups, artificial irritation and the natural stimulus of the movement of the sea-water increase the light, and even induce it, there is still the power of intrinsic self-illumination. Quatrefages points out the extreme sharpness and brightness of the localized spots of light on *Noctiluca*, and insists that in a corresponding mass of them there is as much light given out as from the organ of *Lampyris*. There is, however, this difference between the light. It is extinguished in both *in vacuo*, but it returns only in the *Lampyris*. Two sets of phenomena are probably present, and in the simplest animal the physical cause of the light is probably different from that in the beetle. Certain it is, that all the agents which produce contraction of the protoplasm of *Noctiluca* determine the light, and if a persistent contraction is set up, the light is equally persistent, and death results. As the light comes from spots about the region where growth, the deposition of fresh protoplasm and its differentiation into minute granules are in full operation, and as moderately careful experiment has proved that there is no increase of temperature accompanying the light, the cause of it cannot be referred to "combustion," to oxidation, or to phosphorus, but to local and then general molecular movement of intense rapidity, which can produce light waves. In the instance of the *Pholas* large quantities of this luminous substance can be collected, but the temperature bears no relation to the light. If twenty or thirty female glowworms are put on the hand, which is rendered as visible as by the light of a candle, there is no appreciable temperature above that of the cold, clammy insect. The notion of oxidation of matter producing brilliant light without a measurable amount of heat is of no great value; and certainly if a female *Lampyris* glowing on damp grass so as to be luminous entirely underneath, and to have her light visible for many paces off, could evolve a corresponding or relational amount of heat, she would be fried.

During the daytime, if *Lampyris* be watched, whilst under the shade, she is not luminous as at night, and it is difficult by irritation to get her to shine. Again, there is manifest paling of the light after midnight, and the neighbourhood of the male causes both to flash out more. The influence of nerve is the most manifest in the Insecta, less so when the structure is rudimentary in the Alcyonaria, and it is absent in *Noctiluca*. But still, as the simplest nerve is protoplasm differentiated slightly and formed into masses and long lines; so even in *Noctiluca*, the light, situated as it is, at the very extremity of the thready protoplasm, which is ever streaming at its surface with granular matter, may be said to be in relation with localized potential, the energy of life. The phenomena of the so-called phosphori, or the luminosity of such substances as sulphide of barium, even when the emission of light is brief, is a consequence of molecular change and movement. Certain minerals obtain this movement after exposure to the sun, or to artificial but intense light, and in its production the energy of the light given has been transferred, and, as usual, more or less degraded. One can understand that if there is an energy of life, linked on to the unstable albuminoid, the basis of animal and vegetable organisms, and it can produce heat and electricity, it can, as the highest physical potential, produce molecular movement sufficient to develop light waves.

EXPLANATION OF PLATE VI.

Fig. 1. *Noctiluca miliaris*, magnified 100 diameters, showing the fibrillar structure; the flagellum (*f*): and the cilium at the oral aperture (*s*).

„ 2. *Noctiluca miliaris*, slightly magnified and luminous.

„ 3. *Noctiluca miliaris*, luminous portion highly magnified.

„ 4. *Phyllirhoë bucephala*, showing the luminous spots.

„ 5. *Pyrosoma giganteum*, reduced in size.

„ 6. *Lampyris noctiluca*, female, natural size.

„ 7. The same; the luminous organs enlarged.

„ 8. The male, its luminous organs magnified.

„ 9. The larva, its luminous organs magnified.

„ 10. Some light cells and their tracheæ magnified.

THE BIRTH, LIFE, AND DEATH OF A STORM.*

By ROBERT H. SCOTT, M.A., F.R.S., &c.

WHEN we are asked to give an account of the birth of a storm, we are reluctantly compelled to admit that our storms are, almost without exception, foundlings, and that, as the precise conditions to which they owe their origin are, for the most part, shrouded in uncertainty, warm discussions at times arise as to the parish from whence they have set out on their wanderings.

Dove said long ago that storms were due to the interference of the Polar current or the East wind with the Equatorial current or West wind. He gave the winds these names, because on his views the east winds really consisted of air flowing from the North or South Pole towards the equator, which was modified in the direction of its motion by its change of latitude; while west winds were really due to air endeavouring to make its way back to the Pole from the equator, whose course was in its turn modified by its moving from lower to higher latitudes. To the conflict of these two grand currents, east and west winds, Dove attributed all our storms; but he did not attempt to explain how the currents came into collision.

These views, however correct on their cosmical principles, have been superseded, of late years at least, as regards the explanation of our winds, by the modern views of the relation between the wind and the distribution of barometrical pressure; but, unfortunately, we still remain in comparative ignorance of the ultimate causes to which this distribution of pressure, or the rise and fall of the barometer, are due. To give some conception of the existing difference of opinion on these fundamental principles of our science, I may say that while some authorities maintain that the force of the wind in a hurricane is caused by the amount of barometrical disturbance which accompanies it, others hold

* Founded on a Lecture delivered by the Author at the London Institution, February 3, 1879.

that the fall of the barometer at the centre is itself, in great measure, due to the centrifugal force of the revolving mass of air.

Of the various theories which have been propounded to account for storms, which are generally more or less cyclonic in their character, I shall only mention four.

1. Some authorities, and amongst them our own countryman the Rev. Clement Ley, attribute the formation and subsequent progress of a storm to the condensation of moisture, but they apparently ignore the fact that many of our very heaviest rains do not give rise to cyclonic disturbances of serious character. For instance, when on April 10 and 11, 1878, 4·6 inches of rain fell at Haverstock Hill, we had no storm of wind at all. In partial confirmation of this view, Professor Mohn, of Christiania, points to the accidental condensation of moisture caused by the contact of a mass of damp air with the surface of an extensive snowfield as a possible cause of a storm. About the 61st parallel of latitude the glacier region of Justedal stretches for several miles along the coast of Norway, and this has occasionally been known to exert an influence in increasing the intensity of an existing cyclone, and even in some instances has appeared as the centre of a newly-formed depression.

These gentlemen, moreover, rely greatly on the fact that the rain area which accompanies every cyclonic system is roughly oval in shape, with its longer axis extending in the direction in which the system is advancing, and that by far the greatest amount of rain falls in front of the storm. They do not, however, explain the fact that very heavy rain frequently occurs on the northern side of a depression, where the wind is easterly, and that this circumstance does not indicate a northward motion of the system.

The most serious objection to this theory is, however, that first stated, that not only do the heaviest rains not come with the severest storms, but that frequently they are observed in times of nearly absolute calm.

2. The second theory to which I shall refer is the mechanical one, most strongly urged by Mr. Meldrum, of the Mauritius, whose investigations into the weather over the Indian Ocean have led him to the belief that every cyclone is generated in the intervening space between two oppositely flowing currents of air, of which the easterly moving stream, speaking in the most general terms, lies on the polar side of the westerly wind. Such a disposition of the currrents would be that which would naturally arise were the cyclone once formed.

This view is called seriously in question by Messrs. Blanford and Eliot in their discussion of recent cyclones in the Bay of Bengal, which they have been able to study from very early

stages, and in which they fail to see evidence of the pre-existence of two, and only two, determinate currents.

Another serious objection to this theory is that it does not assign a *vera causa* sufficient to give the *first* impetus to the barometrical fall and the rotatory movement of the air.

3. A third theory of the origin of these storms is that which is strongly urged by M. Faye, in Paris, and is to the effect that, as interfering currents in rivers give rise to vortices which extend from the surface downwards into the water, so all our waterspouts, *trombes*, and even the largest tropical hurricanes must be all formed in the upper regions of the atmosphere, and extend downwards to the earth: the force which gives them their onward motion being supplied by the upper currents.

It is sufficient to say that this theory has not met with acceptance from any practical meteorologist, while it is directly controverted by recent investigation into the motion of cirrus clouds, which show beyond a doubt that the motion of the upper currents of air over a cyclone is outwards, and not inwards, as the descending theory would demand.

Moreover, some of our readers may have noticed in "Nature" of January 16, a notice, copied from the "Times," of the formation on the Lake of Geneva, on January 2, of a veritable small water-spout, 40 feet high and 10 yards in circumference, by the meeting of two winds, known locally as the *Föhn* and the *Bise*, on the surface of the lake. Here the waterspout was raised, and did not descend from the clouds.

4. The last theory we shall notice is that of the late Mr. Thomas Belt, who seeks for the origin of the disturbance on the ground, and, like M. Faye, assigns the same explanation to the smallest dust-whirl eddies and the largest storms which sweep over the earth.

This theory assumes as the first cause the heat of the sun. The heat-rays pass through the atmosphere without warming the upper strata, and so Mr. Belt supposed that over a sandy soil a mass of air close to the ground might rise in temperature much higher than the superincumbent layers of the atmosphere. The lower strata would therefore become lighter, and a condition of unstable equilibrium would arise. This, however, could not last for ever, and, sooner or later, the heated lower air would burst up, and the ascending column thus produced would be the nucleus of the nascent cyclone.

The difficulty in accepting this explanation is that we should like some ocular evidence of such a sequence of conditions. The supporters of the theory, however, point to accredited instances of the formation of whirlwinds over volcanoes like Santorin, and over extensive fires like those of Carolina canebrakes.

In confirmation of these views of the effect of solar heat in producing a depression, I may cite an investigation by Dr. Hamberg, of Upsala, who has found that in July, 1872, after a prevalence of intensely warm weather in Southern Sweden, pressure gave way over the heated area; the isobaric lines following the trend of the coast; and a rotatory movement was thereby generated in the atmosphere above it, resulting in a perfectly formed cyclone which passed on over Northern Finland.

It would appear, therefore, that the production of a cyclonic disturbance may be attributable to more than one agency, as all the theories mentioned have some facts in their favour.

Leaving then this abstruse and imperfectly understood line of inquiry, let us proceed to a subject which yields us results of more immediate practical utility: the character and history of the storms when they have once started on their travels.

I shall commence by saying that a greater mistake cannot be made than to assert that *all* storms are distinctly connected with cyclonic disturbances.

The force of the wind depends on differences of atmospherical pressure over a given area, and the only reason why storms are generally associated with cyclones is that these systems afford us the most serious instances of disturbances of atmospheric equilibrium, and consequently of differences of pressure, which are met with on the globe.

At any place where an area of relatively high pressure comes into close proximity to an area of relatively low pressure, a gale will result, and so a storm may be due just as much to the rise of the barometer in one region as to its fall in an adjacent district.

For the same physical reason, however, that the eddies in a river extend downwards, and the water does not pile itself up in a peak, the normal disturbance of atmospherical equilibrium is the appearance of one of these vortices with pressure decreasing rapidly towards the centre. Wherever there is a rapid decrease there is a steep gradient, and consequently a strong wind.

Defining the term cyclone, in its very widest acceptation, as indicating a region of diminished pressure, round and in upon which the air is moving along paths which are more symmetrical all round the centre the more perfect is the circular form of the system, we must at once see that not every cyclone is accompanied by a storm. The fact is, that the direction and force of the wind are regulated by the difference of barometrical pressure over a given distance, and not in any way by the actual height of the barometer at the station at which the storm is felt, or by the distance of that station from the point where the barometrical reading for the time being is the lowest.

This explanation of wind motion is almost the only new

principle which has been recognized in our science during the present generation, and its practical importance is daily forcing itself more and more into public notice with the development of weather telegraphy. It is usually known under the name of Buys Ballot's Law, and is stated as follows:—"Stand with your back to the wind, and the barometer will be lower on your left hand than on your right."

The truth of this law is evident to anyone who looks at a weather chart, but the Dutch Professor, after whom it is named, though he justly claims the credit of having persistently advocated the acceptance of this relation of the wind to the distribution of pressure, was not by any means the first to discover it.

The final result of all the inquiries into the question is that on the mean of all winds the angle between their direction and the tangent to the isobar at the place is about 20°.

These principles of wind motion have a most important bearing on the theory of the motion of the air in hurricanes and typhoons. The old popular idea of these phenomena is that the air blew round and round the central calm in circles, so that any sailor caught in one of these storms could at once know that when he was hove-to, if he looked in the wind's eye the centre bore eight points to the right in the northern hemisphere, and to the left in the southern; or, what is the same thing, if he was scudding before the wind the centre would lie exactly on the starboard beam in the northern and on the port beam in the southern hemisphere.

Modern meteorologists, however, almost with one voice, declare for a spirally incurving movement as the most probable behaviour of the wind, as would be indicated by the angle which its direction makes with the isobars as just explained; but this view presents no novelty, for it was first stated about forty years ago, and Piddington, in his "Sailor's Hornbook" says that even Redfield, when propounding his "Law of Storms," stated:—

"I have never been able to conceive that the wind in violent storms moved only in circles. On the contrary a vortical movement, approaching to that which may be seen in all lesser vortices, aerial or aqueous, appears to be an essential element of their violent and long-continued action, of their increased energy towards the centre of axis, and of the accompanying rain. In conformity with this view, the storm figure on my chart of the storms of 1830 was directed to be engraved in spiral or involute lines, but this point was yielded for the convenience of the engraver."

We see, therefore, that when we trace back to its origin the belief that any storms are really circular, we find that it was "the convenience of an engraver," which decided the question.

It may be safely asserted that there does not exist for a single

instance of a West Indian hurricane or China Sea typhoon, a sufficiency of evidence to convince any unprejudiced investigator as to what was the true path of the air in the storm. To show this path beyond the possibility of doubt, we require a considerable number of simultaneous observations taken on different sides of the storm centre. These, however, were not forthcoming in the case of a single storm described by Redfield, Reid, or Piddington, so that the authority of the founders of the law of storms cannot be cited as decisive of the question.

This suggestion of spiral motion must of course modify the simple rule for a ship scudding, of looking in the wind's eye, and taking eight points on the starboard or port side for the storm centre, and indicates the probability that the true position of that spot will be at least two or three points ahead of the bearing given by that rule, so that the ship, if scudding, *may be* gradually approaching the most dangerous part of the storm.

The recent investigations of Mr. Meldrum which have been thoroughly confirmed by Captain Toynbee's examination of the Nova Scotia storm of August 24, 1873, lead to the suspicion, not to use a stronger word, that these cyclonic storms are not symmetrical at all, and that at some parts of the system the wind blows directly towards the centre, so that for a ship in such a situation, and scudding before the wind, the centre would lie right ahead.

This is a subject which requires most careful study, in order to see whether or not the time-honoured rules for handling ships in rotating storms require modification.

I shall now leave the subject of the air motion, and proceed to describe the phenomena of a cyclonic disturbance when it passes over us. In the first place, very few of them, in these latitudes, exhibit much approach to a circular shape, as regards the course of the inner isobars, and we may say that none of them develop equal violence in all segments. The reason of these differences in the force of the wind is to be found in the distribution of pressure in the vicinity of the storm area, for if on any side of that area there exists a region of high barometer readings, on that side steep gradients will be produced, and of course proportionably great violence of the wind. The actual weather phenomena of a typical cyclonic disturbance, if plotted on a diagram, show very clearly how cloud and rain prevail over the whole front of the system, and how in the rear, where the wind is north-westerly, the sky clears up. There is one fact worth remembering about these storms, and that is, that just before the sky clears a very smart squall of rain frequently comes on; so that we get this practical hint, if during a westerly gale we find the rain becoming exceptionally heavy we may look for the weather speedily to clear up.

Such a diagram also shows us that it is quite a mistake to consider all east winds as dry ones, for in a cyclonic system the cloud area extends on the northern side, where the wind is easterly, nearly as much as on the southern, where the wind is from the westward. In fact, many of our wettest days occur with easterly winds, when one of these depressions passes to the south of the station where we may be.

I shall now proceed to give a slight sketch of what we have learnt of the movement of storms. This, as far as we can see, is regulated by the position of the areas of high pressure, or, as they are called, the anticyclones. This is a term introduced about fifteen years ago by Mr. Francis Galton, to indicate an area of excess of pressure out from which the air is slowly whirling with a motion opposite to that which it has in cyclones. If we find an anticyclonic area existing over any region, we know that the cyclonic disturbances will skirt round it and develop their strongest wind on the side which lies closest to the district of high pressure.

Thus if the anticyclone lies over France, the cyclonic disturbances will move from west to east over the British Isles. If the area of high pressure lies over England, the depressions will sweep outside the Scotch coast, and reach Norway north of the 60th parallel. If the anticyclone lies to the westward, and the pressure is higher in Ireland than in Great Britain, there is danger of northerly gales on the east coast of England, from cyclonic disturbances travelling southwards over the North Sea.

In every case the cyclone moves with the prevailing wind along its track.

Unfortunately we know very little about the rate at which these storms advance, some of them moving at the extraordinary speed of 50 or 60 miles an hour, as for instance, that of March 12, 1877; while others, like the West India hurricanes, do not attain one-fourth of that rapidity of translation. It is remarkable that the rate of progress bears no relation to the intensity of the storm, the slow moving tropical hurricanes being infinitely more violent than many of our rapidly moving disturbances: although the storm already mentioned in March, 1877, was severe enough, at least in the north of France, to satisfy any requirements.

As regards the distance which storms have been known to travel, I may cite a very long-lived storm, which lasted nearly a fortnight in August, 1873, and which was traced along its course by my friend, Captain Toynbee, by means of the logs of 260 ships which were in the Atlantic during its continuance. Its history will be found in the last published work of the Meteorological Office, "The Weather over the Atlantic Ocean during August, 1873." This particular storm wrought immense

damage on the coast of Nova Scotia. It did not, however, travel as far as Europe, having disappeared in the neighbourhood of Newfoundland. In fact, very few storms have really been proved to maintain their individuality during their transit. Professor Loomis, an American meteorologist, who has devoted much attention during the last 20 years to the connection between European and American weather, has very recently published a paper on the results of discussion of two years' daily synoptic charts of the Atlantic. During that interval 36 areas of depression were traceable across the Atlantic, that is, at the rate of 18 a year. Testing these by wind reports from England alone, he finds that the chance that a storm centre coming from the United States will strike England is only 1 in 9; of its causing a gale anywhere near the English coast it is 1 in 6; while the chance of its causing a strong breeze is an even one.

This brings us to a subject which has attracted an immense amount of public attention in this country and in France: the practical value of the warnings which have been sent over by the "New York Herald" during the last two years. By "practical value" I mean the value to our fishermen and coasting sailors, for whose benefit, more than for that of seagoing men in large vessels, the whole system of storm-warnings has been called into being. It is evident that a warning which is locally unfulfilled may mean a loss of some hundreds of pounds to a fishing fleet; and although the storm to which it referred may have reached some parts of the coasts of Europe, yet if it did not visit the precise district where the fishing was being prosecuted at the time, the fishermen in that district were not benefited by the warning. On the contrary, they were the worse for having received it, on the old principle that "Wolf! Wolf!" should not be cried too often.

Of course, every word that I here say as to the usefulness of warnings is just as true with reference to warnings issued by our own office in London as to those of the "New York Herald," but these latter are often very general in their scope. They speak occasionally of a storm reaching the British Isles and France, and affecting Norway. This haul of the net embraces 25° of latitude, from 45° to 70°, and it is an unheard-of thing that a gale should prevail simultaneously over such an immense tract of coast, so that on each occasion the seamen in many harbours cannot derive immediate benefit from the publication of so vague an announcement.

It is one thing for a scientific man to say that he can recognise the presence of the predicted cyclone on our coast—Professor Loomis admits that the chances are even that he should do so—but it is a totally different matter to prove that a gale which begins two days before, or two days after the time of a

predicted storm, is really the very disturbance which left the American coasts.

The experience of those who have studied cyclone tracks in Northern Europe shows that in winter, on an average, a cyclonic disturbance visits some parts of those regions every fourth day, so that if a warning were announced once a week regularly, there would be nearly a certainty of some sort of a fulfilment.

The results of a most careful comparison of these warnings with the weather experienced by us during the years 1877–78, are given by the following percentage figures :—

	1877		1878	
Absolute success . . .	17·5	42·5	27·0	45·0
Partial success	25·0		18·0	
Partial failure	15·0	57·5	10·0	55·0
Absolute failure . . .	42·5		45·0	

In order to obtain so favourable a result as 45 per cent. of general success, great allowances have been made. Thus it has been considered an absolute success if a gale was felt on *any* part of the coast, whereas the prediction was for *all* parts; and when three separate storms were predicted in one telegram, none of which arrived, only one failure has been counted.

It is, therefore, pretty clear that these warnings have not, as yet, proved themselves to be of much practical utility to our coasting trade and our fishermen. The question is a most interesting one, and although a satisfactory solution of it has not been attained, we need not despair; but we should attack it from the scientific side, and discuss the results in a calm, dispassionate spirit, and through some other medium than that of letters to newspapers.

Let us now leave these American warnings, and see what we know about the movement of storms over Western Europe, which is the problem which most immediately concerns us here. The illustration has often been used that meteorologists, in issuing storm-warnings, and having to estimate the direction and rate of motion of every storm the instant it shows itself in their neighbourhood, are in the position of astronomers expected to assign the path of a comet from the first glimpse they get of it through a break in a cloud—a problem which all will allow to be impossible of solution. Accordingly, great interest attaches to the attempts made from time to time to lay down principles for forecasting the motion of the disturbance.

I have already stated that, as a general rule, the cyclones move round the anticyclones; but this principle requires for its application to storm-warning purposes, access to charts embracing a very considerable extent of the earth's surface. These are very difficult for Englishmen to obtain, as our own daily charts are very limited in area, and frequently do not exhibit even the whole extent of a single cyclonic depression, much less its relation to the distribution of pressure all about it. For

those, however, who can consult such charts it is possible, so to speak, to take their stand at a higher point of view and survey the conditions prevailing, say over Europe, on any given day.

If the amount of change in the pressure or of rise and fall of the barometer during the preceding night be plotted every morning on such a chart, it is found that the path of the system for the day does not lie directly towards the region where the greatest fall has occurred during the night, but is regulated to a certain extent by the direction of the line drawn from the point of greatest fall to that of greatest rise.

Another theory of storm motion, strongly held by those who attribute all our storms to condensation of vapour, is that the track of the depression is always directed towards the region where the air is dampest. This principle, like that just noticed, can hardly be turned to account in this country for our own practical benefit, inasmuch as the whole of these islands appear to be almost equally damp, owing to the proximity of most of our telegraphic reporting stations to the sea.

Other suggestions have been made in various quarters, with the view of throwing light on this very important subject; but we cannot say that the results have met with general acceptance, and the matter urgently demands further study.

I must now come to the final portion of my theme—the Death of a Storm; and on this subject, unfortunately, I have very little to say. As we have not been able to produce evidence of the birth of a storm, so have we never been lucky enough to find any one who was in at the death. In fact, some French meteorologists have hazarded the statement that storms can travel all round the world until at last they travel off it.

Storms have been traced from the Pacific coast of North America across the Atlantic; but these instances are necessarily rare, and, as far as European experience goes, no storm arriving from the Atlantic ever travels far into Russia. This fact is, of course, very much in favour of the condensation theory of storm generation, which has already been noticed. The advocates of this view plead very plausibly that, as the moisture in the air is the food of the storm, so, where that moisture is deficient, the storm dies of starvation.

We may, however, point out to them that eddies in a river and dust whirls at street corners waste and wane without any assistance from vapour condensation.

In conclusion, though it is a humiliating confession for us to make, meteorologists are as yet entirely in the dark as to the reasons why one depression fills up while another becomes deeper. As I have already stated, no meteorologist is able to give a straightforward answer to the simple question, What causes the barometer to rise or fall?

ON THE EXTINCT ANIMALS OF THE COLONIES OF GREAT BRITAIN.*

By Prof. RICHARD OWEN, C.B., F.R.S., &c.

At the conclusion of my student's career at Paris, in the time of Baron Cuvier, my first application of that great teacher's "Laws of Reconstruction of Extinct Animals from their Fossil Remains" was to those of the British Isles,† of which study the results, as relating to the mammals,‡ birds, and reptiles, § have been published.

I next turned my attention to the fossil evidences of these classes of animals in the Colonies of the Empire; and I propose to submit to the Royal Colonial Institute, on the present occasion, the chief results in relation to the Cape of Good Hope, Australia, and New Zealand.

Cape of Good Hope.

My present notice of the evidences of extinct animals of the Cape of Good Hope will be limited to those of the Reptilian class, to which the South African crocodiles, tortoises, lizards, and toads are now the animals nearest akin. Of fossil remains of serpents I have received none; nor are any of the fossil reptiles which have reached me from the Cape allied in genera, families, or even orders, to those now existing in the world. All the Cape subjects of my attempts at restoration are from what are commonly termed the "Karoo beds," covering an area of over 200,000 square miles, extending between latitudes 35° and 33° 30′ S. and longitudes 20° and 28° E. They overlie deposits

* A paper read before the Royal Colonial Institute, May 6, 1879, and printed here by permission of the Author.

† "Reports of the British Association," vols. for 1839, 1841, 1842, 1843.

‡ "History of British Fossil Mammals and Birds," 8vo. 1846. (Van Voorst.)

§ "History of British Fossil Reptiles," 4to. Parts I.–VI. 1849–55. (Published by the Author.)

of Devonian and Carboniferous age, and include those answering to European Permian and Trias, and consequently are of older date than the Oolites and Liassic cliffs in England from which have been derived, among other strange reptilian forms, the numerous kinds of ichthyosaurs and plesiosaurs.

The Cape fossils are imbedded and petrified in shales and rocks of quartzose sandstone, the strata of which slightly incline in their southern verge from horizontality. They seem to have been deposited from lacustrine or estuarine waters during a lapse of time which may be conceived from the mountain ranges into which they are now elevated. The following vertical thickness of the fossiliferous strata has been ascertained: at the Stormberg Beds, 1,800 feet; at the Beaufort Beds, 1,700 feet; at the Koonap Beds, 1,500 feet; at the Upper Ecca Beds, 1,200 feet. These stratified beds, or basins, of ancient waters, have been, in the course of their upheaval, traversed by trap dykes, and the consolidating and elevating forces to which the shales have been subjected have converted them into the hardest and most intractable rocks that my chisel ever operated on: they "strike fire" at every blow. The difficulty of extricating the imbedded teeth and bones of the strange creatures that haunted the banks and shallows of the ancient lakes or estuaries is enhanced by the near correspondence in colour of the petrified parts to the dark, often black, rock in which they are enclosed.

In the year 1838 Mr. Andrew Geddes Bain, employed in the construction of a military road north of Fort Beaufort, observed in parts of the rock he was blasting portions like teeth and fragments of bone; these he transmitted to the Geological Society of London, and they were referred by the Council to me to report on. The result was so novel that Mr. Bain was encouraged to persevere in the collection and transmission of such evidences, and received for that purpose grants of money from the Geological Society and from the Trustees of the British Museum. I kept up communication with Mr. A. G. Bain until his demise, and have continued the same with his son, Mr. Thomas Bain, the present Surveyor of Roads to the Cape Colony.

The rich series of fossil evidences from these gentlemen have been supplemented by specimens transmitted by successive Governors (Sir George Grey, K.C.B., and Sir Henry Barkly, K.C.B.), by H.R.H. the Duke of Edinburgh, by Dr. Guybon Atherstone, of Graham's Town, by Dr. Rubidge, by J. M. Orpen, Esq., Government Surveyor of the Cape, and by several friendly colonists.

Besides separate Reports and Memoirs in the "Transactions" of the Royal and Geological Societies, the fossils so received

have afforded subjects filling seventy plates of a quarto work of 100 pages of text. *

I think the most extraordinary, as it was the first to be restored, of the old Cape reptiles was a creature attaining the size of a walrus, and which, like that amphibious mammal, had a pair of long, pointed tusks descending from the upper jaw. But it had no other teeth, and it combined the two-tusked character with a lower jaw, edentulous, like that of a tortoise, and a skull exemplifying crocodilian and lacertian structures. Many species of this type, varying in size, came successively to hand, and exemplified the genus called *Dicynodon*. Other two-tusked reptiles required a distinct generic section, called *Ptychognathus*. A third extensive series carried the tortoise likeness further by the absence of tusks, but with the same composite cranial structure as in the Bidentals; and, in short, a series of Reptilia was brought to light which necessitated the formation of a new order in the class, to which was assigned the denomination of Anomodontia.

Now, although no true coal has been met with in the Karoo strata, although present in the older Devonian series, at the Cape, called the Kowie Coal Beds, yet remains of a rich series of vegetation on the land traversed or occasionally visited by the Karoo reptiles have been detected. I was not surprised, therefore, to receive evidences of huge herbivorous dragons, akin, although remotely, to our own liassic scelidosaurs and the Wealden iguanodons.

The jaws of the *Tapinocephali*, of the *Pareiosauri*, and of the *Anthodons* were armed with close-set series of equal-sized teeth, having crowns adapted to crush and pound vegetable substances, and were associated with modifications of the skull for horizontal grinding movements of the jaws. A significant fact was elicited by scrutiny, and sections of parts of the backbone of these Dinosauria. The bodies of the vertebræ retained more of the fœtal structure than has been met with in any post-triassic herbivorous reptile. Those of *Anthodon*, for example, were bi-concave, as in fishes; and those of *Pareiosaurus* and *Tapinocephalus* carried the primitive embryonal character a degree further. The apices of the hollow terminal cones, which nearly meet in the centre in *Anthodon*, quite meet in the other genera, exemplifying the persistence in those huge dragons of a continuous, beaded notochord. Hence the necessity of placing them in a distinct section of Dinosauria, called "Tretospondylia," and it may be, as our restorations become completed, that erpetologists will regard them as the types of an order distinct from the later forms of Dinosauria.

* "Description of the Fossil Reptilia of South Africa," 4to. 2 vols. 1876. By Professor Owen. Published by the Trustees of the British Museum.

In the Trias of Europe had been found the jaws and portions of skull of a fossil creature provided with large flattened crushing teeth, like a pavement covering the palate above, and the correspondingly broad tracts of the under-jaw. These fossils were referred by Agassiz and H. von Meyer to a supposed extinct fish *Placodus*. The first specimen of this rare genus that came to my hands, from Germany, showed, however, characters which led me to think it was a reptile, not a fish. It was with much pleasure, therefore, that I found among the Cape fossils an unequivocal and larger extinct reptile, provided with similar crushing teeth, and with these only; forming, likewise, a pavement upon the palate opposed to similar teeth on a broad alveolar tract of the lower jaw. Since describing and figuring this fossil, under the name *Endothiodon*, I have lately received a second species of the same genus, also from the Karoo beds. It is, of course, significant to note that the only analogous form of reptile from localities elsewhere than at the Cape had left its remains in deposits of Triassic age. At the present day, the only known aquatic vertebrates adapted by their teeth to crack and crush shell-fish belong to the class of Fishes: such, for example, are the Wolf-fish (*Anarrhichas*) and the Port Jackson Shark (*Cestracion*).

An extensive series of Reptilia has been brought to light from the Cape fossiliferous beds above specified, which were of a more strictly and decidedly carnivorous nature than the Dicynodonts, combining upper tusks of a more piercing and trenchant character opposed to a pair of similar tusks below, crossing in front of the upper pair when the mouth was shut. These killing and holding teeth, like the canines, or laniary teeth, of the lion and dog, were preceded by incisor teeth of a similarly pointed shape, and followed by molar teeth, of the character of those called carnassial or sectorial in Mammalian feræ. This type of dentition, in which the "incisors," "canines," and "molars" can be specified on characters of size, shape, and relative position, had hitherto been unknown, save in the Mammalian class; but it is combined in these extinct Cape creatures with a true reptilian or cold-blooded cranial and vertebral structure. With this guiding evidence of the reptilian class of our present series of fossils, I further found, associated with such dentition, that the teeth were retained, as in Mammals, sufficiently long for the fangs to dwindle and become consolidated at the implanted end; that the humerus, with ridges and processes adapted to as free evolutions of the fore-paw as in the lion, also showed a canal for the passage and defence of a brachial artery and nerve, not present in any existing kind of Reptile, but characterizing the humerus in many, especially feline, carnivorous Mammalia. Furthermore, that the paws were supported by joints or pha-

langes in the same numbers, or according to the same formula, as the Mammalian paw.

Detecting many and various modifications of this carnivorous reptilian type, I felt constrained to group them into a distinct order, called Theriodontia. This order was exemplified in South Africa by a species and genus (*Titanosuchus ferox*) surpassing the lion in size; by others as large as a leopard (*Lycosaurus pardalis*); and by others, again, as small as a cat or foumart (*Galesaurus* and *Procolophon*). I may also note a fact of some significance, that the incisive formula in the Theriodonts is not that of the higher or placental Mammals, but of the lower, more reptilelike, marsupial ones. Thus, *Cynodraco* has $i\frac{5-5}{4-4}$, like the opossums (*Didelphis*); *Lycosaurus* has $i\frac{4-4}{3-3}$, like *Thylacinus* and *Sarcophilus* (the native hyæna and devil of the Tasmanian colonists); while the placental Carnivora never show more than $i\frac{3-3}{3-3}$.

In the existing Reptilia the characters above specified are wanting. They would have been unknown and unsuspected as reptilian ones, save for such researches as are here summarized. If the gap in the series of animals continued from the Triassic to the present period had not been filled up otherwise than by reptiles, the living remnant of that class would have testified to total loss of such gains of organization as had enriched the predecessors of modern tortoises, lizards, and crocodiles.

We now know, through discovery and study of fossil remains, that not one of the gains which benefited our extinct reptiles has been lost, but has been handed on, and advanced through a higher type of vertebrates, of which mammalian type we trace the dawn back to the period when reptiles were at their best, grandest in bulk, most numerous in individuals, most varied in species, best endowed with kinds and powers of locomotion, and with instruments for obtaining and dealing with both animal and vegetable food.

Then obtrudes the question, and will not be parried, Has the transference of structures from the Reptilian to the Mammalian type been a seeming one, delusive, due to accidental coincidences in animal species independently created? Or, was the transference real, consequent on the incoming of modified species by way of descent, and through the operation of a secondary law? Certain it is that the lost reptilian structures defined in this paper are now manifested at the Cape of Good Hope by quadrupeds with a higher condition of cerebral, circulatory, respiratory, and tegumentary systems. But into these higher generaliza-

tions of biological science it is beside my present purpose to enter.

I therefore next proceed to notice the Extinct Animals of the Colony of

New Zealand.

When Cook re-discovered,* or, for us, virtually discovered New Zealand, in 1769, he was accompanied by Solander, a pupil of Linnæus, and by Joseph Banks, an ardent collector of facts and objects of Natural History. They made every effort, and tried every means of inquiry of the friendly natives, in pursuance of their quest. A dog, resembling that which they had seen in the Polynesian islands, and probably introduced into New Zealand by the Maories, was noticed, and a species of rat was obtained, which was fostered for food by the natives. Bats had flown thither, but no wild land-mammals were seen or heard of. Although Captain Cook was enjoined by the "Admiralty Instructions" to bring home "any extraneous fossils" he might meet with, none such were obtained in New Zealand; nor could any information be extracted as to any beast or bird notable for its large size that then existed or had existed in the island. In the Maori "Vocabulary" appended to the "Voyage," neither the word "Moa" nor "Movie" occurs. The natives gave no sign that they knew anything of gigantic birds which had served their ancestors for food.

Subsequent expeditions, having natural history more directly in view, sent out by the French Government, were equally unsuccessful. The accomplished zoologist Lesson, accompanied the *Voyage de la Coquille* in 1820. MM. Quoy and Gaimard were attached to the *Astrolabe* (1827). The *Zoologie* of both voyages was brought out in detail and with rich illustrations by the French Government, but no clue to the singular extinct avifauna of New Zealand was obtained. Confirmation was recorded of the small wingless bird, the Kivi, of which Captain Barclay of the ship *Providence*, had brought to England a skin, in the year 1812; but no idea was suggested of the gigantic race of which that bird has proved to be the sole survivor.

One afternoon in the year 1838, as I was preparing for a lecture, an individual was announced, who unwrapped a bone which he stated he had obtained in New Zealand from a native, who told him it was the bone of a great eagle, and for this specimen the man asked the sum of ten guineas. I assured him he had been misinformed, that no bird of flight had a bone

* Abel Tasman reached the west coast of New Zealand in December 1642. He made no observations on the animals or products of the islands, and departed, after the slaughter by the natives of four of his crew.

of that structure; that it was a "marrow-bone," in shape and size like those brought to table wrapped in a napkin.

To further questions as to its locality, the vendor replied by showing, among other evidences, a jade-stone weapon, which I knew to be peculiar to the New Zealanders; and he still attached so much value to the unpromising fragment, that I consented to try to make out the bone if he would leave it, and call the next day.

After "lecture," I took the bone to the skeleton of the ox, expecting to verify my first surmise; but with much resemblance to the shaft of the thigh-bone, there were precluding differences; from the arm-bone (*humerus*) of the ox, which also affords the tavern delicacy, the discrepancy of shape was more marked. Still, led by the thickness of the wall of the marrow-cavity, I proceeded to compare the bone with similar sized portions of the skeletons of the various large quadrupeds which might have been introduced and have left remains in New Zealand.

In the course of these comparisons I noted certain superficial impressions which recalled to mind similar ones which I had observed on the surface of the bones of some large birds. Thereupon, I proceeded to the skeleton of the ostrich. The "bone" tallied in point of size with the shaft of the thigh-bone in that bird, but was different in shape. In the latter character it was more like the thigh-bone of the cassowary; but it differed in a more important particular from that bone in the ostrich, cassowary, emu, rhea, and eagle, inasmuch as in those birds the femur is "pneumatic," or contains air, whereas the huge bird's bone in question had been filled with marrow, like the thigh-bone of a beast.

I was almost staggered by the conclusion in which I was landed. Could a bird as big as an ostrich, and of a more massive build, have ever found subsistence in so small an island as New Zealand? All analogy seemed against it. The ostrich has the whole continent of Africa for its home, the rhea roams over South America, the emu over Australia, the cassowary over New Guinea!

These considerations, indeed, told more strongly with the then master-ornithologists, my seniors, Vigors and Yarrell, and to whose judgment I looked with due deference. Yet their scepticism was more natural from their not being practically familiar with the force of palæontological evidence. And, as I urged, this huge bird, if I could be credited, was new to Science, and so might as well have come from New Zealand as from anywhere else. In short, the "Paper" was admitted into the "Transactions" of the Zoological Society, with one plate, giving four views of "the bone" in question.

On the publication of the volume in 1839, one hundred extra copies of the paper were struck off, and these I distributed in every quarter of the islands of New Zealand where attention to such evidences was likely to be attracted.

At that date their acquisition to Great Britain was mainly promoted by the "New Zealand Company," whose agent, Captain William Wakefield, was zealously carrying out the principles of colonisation advocated by his brother, Edward Gibbon Wakefield. Through J. R. Gowen, Esq., a director of the company, the distribution of my paper was recommended and efficiently carried out by Captain Wakefield.

The missionary promptly worked in the track of the colonist. Imperial recognition became inevitable. First a Governor, then a Bishop, Dr. Selwyn; afterwards a Chief Justice, my friend Sir William Martin, went out. Upon each and all I pressed the claims of the possible big bird of New Zealand to attention according to leisure and opportunity. The years 1840 and 1841 passed, and I began to doubt, but misgiving went no further than as to locality; of the bird itself I may say I was "cock-sure." Toward the close of 1842 came the welcome letter of the Rev. William Cotton, M.A., companion of the Bishop, announcing the discovery of big bones in the North Island; and this was followed by the arrival of a boxful transmitted by a fellow-missionary, now the Right Rev. Bishop Williams, to Dr. Buckland, by whom these specimens were generously confided to me for description. They included a nearly perfect specimen of the bone of which I had received the shaft, and with it the other bones of the hind limb of the same bird. These afforded adequate grounds for defining a genus *Dinornis*, and a species *struthioïdes*. But what I was not prepared to see, and saw with amazement, were similar evidences of a larger species of the same genus, a *Dinornis ingens*, and other remains of a still larger kind, *Dinornis giganteus*. But might not these be parts of individuals of the one and the same gigantic bird at different stages of growth? The answer to this question is given by the well-marked characters of immaturity which the bones of the bird's leg display, and especially the third or metatarsal bone, which is a compound one, and does not acquire the consolidation or coalescence of its three or more constituent elements until maturity is reached. Moreover, with the above evidences of birds of the same genus, surpassing in size any previously known, were others of smaller size, also of full-grown birds. They indicated the former existence in New Zealand of a *Dinornis casuarinus*, a *Dinornis dromioïdes*, a *Dinornis otidiformis*, so called as agreeing in size respectively with the cassowary, the emu, and the bustard. Of the latter I subsequently received remains justifying its title to a distinct genus,

Aptornis. All the others belonged to the genus *Dinornis*. Correspondence was kept up with every contributor in New Zealand of specimens and of information bearing upon this new chapter in Ornithology. Year by year accessions of fossils reached me; all were of the class of Birds.

No evidence of an extinct mammal or of an extinct reptile has hitherto been obtained from the comparatively recent formation yielding the avian remains. The progress of restoration was in two directions, one in perfecting a knowledge of the entire skeleton of an individual, the other of the specific and generic modifications of these extinct wingless birds. The law of correlation, justifying the affirmation from the first fragment that the bird was terrestrial, incapable of flight, proportionately heavier and more sluggish than the ostrich, was vindicated by the discovery of the small and keel-less breast-bone, and by the relatively still smaller scapular arch, which, moreover, indicated an entire want of wings by the presence of a ridge where the socket for the main wing-bone should have been, and where it exists in the ostrich, and also in the apteryx, in which the wing is reduced to the smallest relative dimensions among existing birds. If any still smaller rudiments of a humerus should have existed, and have been suspended by ligament to the scapulo-coracoid arch, in *Dinornis*, such specimen has not yet reached me. Means of restoring the skull, the pelvis, the vertebral column, and the entire foot successively arrived.

The next and very remarkable kind of *Dinornis* was characterized by the relative thickness of the bones of the hind limb, and suggested the epithet *elephantopus*. This elephant-footed bird was as tall as an ostrich, but must have outweighed two, at least, of that largest of living birds—the "*Avium maxima*" of Linnæus. But I was favoured next to receive remains of a *Dinornis* which as much surpassed in size the *giganteus* as did this the *ingens*. Deeming then, as now, that the limits of bulk were surely reached, I committed myself to the *nomen specificum* of *Dinornis maximus*. Of this stupendous bird you may see the skeleton in the British Museum. I thought the articulated casts of that of the *Megatherium giganteum* a suitable equivalent, in which the accomplished founder of the Natural History Museum at Christchurch, Canterbury Province, South Island, concurred. Dr. Von Haast has had the same pleasure in adding that evidence of one of the hugest extinct mammals to his museum at the Antipodes as I have experienced in the addition, due to his discovery in the Glenmark swamp of the maximised Moa, of the skeleton of that bird in our National Museum at home.

The species of *Dinornis* now more or less completely restored are fifteen in number: viz., *struthioïdes*, *ingens*, *giganteus*,

dromioïdes, *casuarinus*, *rheïdes*, *crassus*, *gravis*, *gracilis*, *geranoïdes*, *robustus*, *elephantopus*, *curtus*, and *maximus*. The last two exemplify the opposite extremes of size in the extinct genus.

Our knowledge of these extinct wingless birds, is not, however, restricted to their osteology. Some have left their remains in caves, and under other conditions, which have enabled us to study and compare portions of their skin, and even their plumage. The feather, as in other flightless birds, had loose barbs, and it was provided with an after-shaft, two feathers growing out of one quill, as in the cassowary. Of the skin of the sole of the foot, and of the form and substance of the toes, I have had evidence from footprints in tidal clay, and from casts of such; I have also received evidence of the eggs of the *Dinornis*. Perhaps one of the richest localities of the remains of these extinct birds of New Zealand was discovered by the Rev. Richard Taylor, M.A., of the missionary station at Wanganui, near or along the shore at Waimate. "It appeared," he wrote, "to be a regular necropolis of the race." From this locality was obtained the specimens subsequently obtained by purchase from Mr. Walter Mantell, for the British Museum.

The spread of colonies in different parts of both islands of New Zealand, with concomitant growth on my part of correspondence and appeals for search, collection, and transmission of fossil remains, have resulted in a corresponding harvest of such evidences, from which, besides the confirmation and restoration of the above-cited species of *Dinornis*, indications of other extinct wingless or short-winged birds have been received. They have included two kinds of coot, one (*Notornis*), of the size of a turkey, the other (*Aptornis*), nearly as big as a cassowary; a third kind of bird (*Cnemiornis*), in the leg-bone of which characters like those of a natatorial bird (*Colymbus*) were pointed out,* was subsequently shown by Dr. Hector, of Wellington, New Zealand, who obtained an entire skeleton, in the North Island, to be most nearly allied to a large anserine bird (*Cereopsis*) still living in Australia.† But in the still larger extinct goose of New Zealand, as in the large coots and kivis, the wings had become too small for flight.

The most remarkable exception to this flightless character of the extinct birds of New Zealand was discovered in the Glenmark swamp, in the form of bones having the nearest resemblance to those of the Kahu Harrier-kite of the island (*Circus Gouldi*), but of a size surpassing those of the largest condor or

* "Trans. Zool. Soc.," vol. v. (1865).

† "Proc. Zool. Soc.," 8vo. 1874. "Wingless Birds of New Zealand," 4to. vol. i. pp. 238, 365; pls. lxvi.–lxx. xcv. ci. civ.

lammergeyer.* I suppose this huge bird of prey may have harried and carried off the chickens of the gigantic Moas; and that the extinction of the *Harpagornis*, as it has been termed by its describer, the accomplished naturalist, Dr. Von Haast, may have followed as a consequence that of its prey. So grand a bird of flight could hardly have escaped the notice of the natives with whom Banks and Solander communicated, or of such an acute ornithological observer as the monographer of the existing avifauna of New Zealand, Mr. Buller, of Wellington. It may be that some lingering tradition of the bird led the Maori, from whom the first indication of the fossils of New Zealand was obtained, to call it "the bone of a great eagle."

More than one story of still existing Moas have found their way into New Zealand newspapers; but, like those of the great sea-serpent, they lack the data requisite for scientific acceptance. In both cases the proper attitude of the naturalist is the "expectant" one.

When the first portions of the skeleton were described and figured in 1847, upon which the former existence of the great flightless coot of New Zealand was affirmed, the *Notornis* was concluded to have passed away as completely as the *Dinornis*. But it fortunately happened that Mr. Walter Mantell, visiting the south-west part of the South Island, in 1849, came upon a party of seal-fishers who had captured the living bird on the shores of Dusky Bay, and had luckily kept the skin after cooking and eating the unique specimen. The skull and leg-bones brought to London with this served to identify the species and genus; the skin, beak, and feet confirmed the inference from the fossils. This specimen of *Notornis Mantelli* was purchased by the British Museum, where it may now be seen. †

I suppose that any captor who should bring his *Dinornis* alive to London might reckon upon a rich reward from the Council of the Zoological Society.

At present all I have been able to get, besides the bones, have been brains,‡ rings of the wind-pipe,§ gizzard stones,‖ eggs, feathers,¶ and bits of skin,** of unquestionable Moas. But how about the brain, it may be asked, unless you had a fresh bird? A very pertinent question. The brain is represented by a cast of the interior cranium. It is relatively smaller than that of

* Op. cit. vol. i. p. 141; pls. cv. cvi. cvii.

† *Notornis Mantelli* is figured of the natural size as frontispiece to my work (4to. 2 vols. 1879), "On the Extinct Wingless Birds of New Zealand."

‡ Op. cit., p. 326, pl. xci. fig. 11.

§ Ib., p. 327, pls. xcii. xciii.

‖ Ib., p. 337, pl. xcii. fig. 8.

¶ Ib., p. 440, pl. cxiv. figs. 8–11.

** Ib., p. 443, pl. lxxi. and pl. cxiv. fig. 7.

the ostrich, which is reckoned the least intelligent of living birds.

My first acquaintance with the eggs of *Dinornis* was founded on the fragments of the shell obtained from ancient cooking-pits.* Thereupon I broke up an ostrich egg into similar fragments; then compared the curves of their outer surface. The long and the short diameters, *i.e.* the longitudinal and the transverse dimensions of the egg, were thus indicated in the ostrich fragments; by like indications in those of the bits of the *Dinornis* egg-shell, I recomposed the longitudinal and transverse contours of the entire egg, as shown in Plate XC. of the undercited work; and such egg I hypothetically referred to the *Dinornis elephantopus*.†

In the year 1865 the entire egg of a larger species was sent to London, and submitted to my inspection. It fetched 100*l.* at the sale by auction at Stevens's rooms. Its history is as follows:—A colonist, digging the foundations of a store at Kaikoura, Canterbury, New Zealand, came upon the skeleton of a Maori, who had been buried in a sitting posture, and upon his lap had been placed, at the interment, this egg. His greenstone adze was also found in the grave. From the superiority of length of this egg to that ascribed to the *Dinornis elephantopus*, with a minor degree of transverse diameter, I conceived it might belong to the taller and less robust species, *Dinornis ingens*.‡ I subsequently received from Dr. Hector intelligence of the discovery of an egg of the *Dinornis crassus*, containing some bones of a partly-hatched chick; they included a sternum, pelvis, coraco-scapular arch, showing the unequivocal characteristics of their genus,§ but no wing-bones. On these and some other data I have formed an estimate of the size of the egg of the *Dinornis maximus*, at sixteen inches by twelve inches in the two diameters.‖

The living Kivi (*Apteryx*) is remarkable for the large proportional size of the egg, of which it lays but one at each procreative season. It is probable that its extinct gigantic kindred could as little afford a relatively greater incubating area to the shelly case of their embryo.

Of the numerous transmissions from divers localities in both islands of New Zealand, not any have included a bone of a land-mammal having any claim to be considered an aboriginal

* "Proceedings of the Zoological Society of London," Part xx. 1852, p. 12.

† "Memoirs on the Wingless Birds of New Zealand," 4to. vol. i. p. 317, pl. xc.

‡ Ib., p. 318, pl. cxvii.

§ Ib., p. 319, pl. cxv.

‖ Ib., p. 320, pl. xcix.

species, or belonging to one which nas become extinct, and would have been otherwise unknown. Now and then, though rarely, the bone of a rat, of the Maori dog, and of a seal could be picked out.

New Zealand never had an indigenous Mammalian fauna comparable to the rich Marsupial one of Australia. A bat or two flits in its atmosphere, seals haunt its coasts, and thereupon is occasionally stranded the carcase of a whale.

When the Maori first landed he found no kangaroo or other herbivorous beast to yield him flesh. The sole source of that food, the more needed from the absence of the bread-fruit and cocoa-nut trees which he had left at Hawaii, and the colder climate of the land to which he had been driven, was in the various kinds of huge birds incapable of flight. These, it is evident, had overspread both islands. The rich development of ferns, with nutritious elements in unusual proportion in the roots, of which the Maoris still avail themselves for their favourite bread, formed a perennial table for the support of the feathered bipeds, to which divers other kinds of vegetable nourishment were doubtless added.* Foot-prints on the sea-shore suggest their varying their diet by picking up marine animals. For how many centuries before the unfeathered biped appeared the Dinornithidæ had roamed supreme over the islands there are no adequate grounds for estimate.

There are evidences of different kinds that the extirpation of the extinct birds of New Zealand was the work of man.† The question of the origin of these wingless species is a deeper one. Into that I have entered, as far as there seemed to be any data for guidance, at the conclusion of the work on the subject of the present section of the communication now offered to the Institute.‡

Australia.

I finally proceed briefly to state the chief results of palæontological research in the Colonies of Australia, restricting the present notice to the extinct species of the Mammalian class. The labours of zoologists in the discovery and determination of the existing kinds have made generally known the fact of the prevalence in the Australian continent of the peculiar group called Marsupialia, or pouched beasts; those, viz., which produce their young prematurely as compared with the rest of the class, and transfer them to a skin-bag covering the teats, to which the embryo remains attached till it gains the size and

* See the section "On the Food, Nests, and Traditions of the Moas," Op. cit. vol. i. p. 450.

† Ib.

‡ Op. cit. vol. i. p. 460.

strength of the ordinarily born young in the more highly organized or placental Mammalia. But one existing genus of these Marsupials is known elsewhere in the world—the opossums, viz., of America (*Didelphis*, Linn.). Our knowledge of the various modifications of the Didelphs of Linnæus has been derived exclusively from the remnant of that vast Melanesian continent of which Australia, Tasmania, New Guinea, and a few outlying insular fragments now remain. The carnivorous kinds are represented by the Tasmanian Thylacine, of the size of the wolf, by the somewhat smaller Sarcophile or Devil of the Tasmanian colonists, and by still smaller Dasyures or native cats and weasels of Australia. The insectivorous kinds are represented by the bandicoots (*Perameles*, *Myrmecobius*, *Chœropus*); the frugivorous species by the arboreal phalangers, koalas, and petaurists; the root-eaters by the burrowing wombats; the grazers and browsers by the numerous and varied family of the saltatory potoroos and kangaroos. The largest existing marsupial in Australia is the Boomer kangaroo (*Macropus major*). The skull of the biggest kangaroo which has come under my observation does not exceed eight inches in length. Such a kangaroo will outweigh by one-half the biggest thylacine.

John Gould, in his beautifully illustrated work on "The Mammals of Australia," gives the length of 2 ft. 2 in. to the wombat of Tasmania (*Phascolomys ursinus*); the bones of the *Phascolomys latifrons* of the Australian continent indicate a somewhat larger animal, but the skull scarcely exceeds 7 in. in length. The skull of the largest of the extinct wombats is more than a foot in length.

Between this and the largest existing wombat were two other species of intermediate dimensions; there were also wombats distinct in kind, but resembling in size, the two or three existing species; finally, there existed a smaller species in Australia. All these have passed away. Admitting the specific distinction of the two kinds of wombat now living in Australia, and that of the sole existing Tasmanian species, fossil remains have made known the former existence of seven kinds which have become extinct. These wombats ranged from the size of a marmot to that of the European bear (*Ursus arctos*), and the distinctive characters of the largest kind are of generic value.

The fossil evidences of kangaroos are more abundant and varied than those of the wombats. I shall limit myself to a brief notice of the larger extinct kinds.

I have referred to the dimensions of the skull of the biggest known existing kangaroo.

The first extinct species represented by the fossils obtained by Sir Thomas Mitchell, from the caves of Wellington Valley, had a skull of 10 in. in length. I called it *Macropus Titan*,

not anticipating in 1836 to find it but a middle-sized species. Subsequently I received evidences of a kangaroo with a skull of 12 in. long; and next, of one with a skull as large as that of a full-sized ox, 16 in. in length.

Now, these extinct species do not differ merely in magnitude from each other, and from the smaller existing kinds, but in modifications of the teeth and in the proportions of the limbs.

As the kangaroos gained in bulk they lost in power of leaping. The hind limbs were less disproportionately long, the fore limbs less disproportionately short. Both pairs took a more equal share in the support and progression of their bulky frames. Nevertheless, all the well-marked characteristics of the macropodal foot were retained, the modifications being restricted to those of size and proportion of toes and leg-bones.

So likewise with the teeth. Certain teeth of extinct kinds were shaped for cutting, the same teeth in other kinds for pounding.

Species not exceeding or inferior in size to existing kangaroos manifested specific distinctions in the teeth, in the skull, and in parts of the skeleton. I have had to name and characterize a score of kinds of kangaroo that have existed in Australia and have passed away; and these extinct species have made known to the zoologist seven generic modifications of the macropodal family, distinct from any of the genera still represented by known living kinds of kangaroo.

The most interesting result of these comparisons of the fossil remains of kangaroos were the indications of a gradual resumption of the more ordinary quadrupedal character in the larger extinct species. This transition I found to be completed in still larger forms which retained, in the main, the macropodal type of dentition, the modifications of the teeth indicating a more strictly herbivorous character of quadruped.

The first of these forms was manifested under three specific modifications, on which have been founded a *Nototherium Mitchelli*, a *Not. Victoriæ*, and a *Not. inerme*. Of this genus I have as yet, indeed, obtained little more than portions of the skull and teeth. But a few detached bones of the ankle show a deviation from the kangaroo type of foot toward that of the ordinary character, and an arm-bone indicates a more equal size with stouter proportions of the fore and hind limbs. I infer the *Nototherium* to have resembled in general character a large tapir, but it was essentially a marsupial quadruped.*

Amongst the cave-fossils submitted to me in 1835 by Sir

* An entire skull of the *Nototherium* has been discovered. It is now in the Museum of Natural History at Sydney, the Trustees of which have transmitted a cast to the British Museum.

Thomas Mitchell, and which are described and figured in the "Appendix" to his "Three Expeditions into the Interior of Eastern Australia" (2 vols. 8vo. 1838) was the fore-end of one-half of a lower jaw with the implanted end of a fractured tusk. It indicated a beast as big as a hippopotamus. This fossil and a limb-bone, sent to Paris, of what I subsequently determined to belong to the same species, had given rise to the notion that a true hippopotamus and an elephant had left their remains in the caves and drift deposits of Australia.*

After an extensive and minute comparison of the tooth-stump from Wellington Valley with every quadruped of similar size having such a tusk at the fore part of the under jaw, I came to the conclusion that it must have belonged to a distinct kind of animal; that the tusk had been one of a pair like the lower incisors in the kangaroos, wombats, and phalangers; and that the fossil, therefore, indicated the former existence in Australia of a marsupial quadruped as big as a rhinoceros or hippopotamus; but, being of a distinct genus and species, I described and figured it as representing a new form—*Diprotodon australis*.

But what would this problematical *Diprotodon*, guessed at by a bit of a tooth, turn out to be?

Now, here I may remark that there is no chase in the sporting world so exciting, so replete with interest, so satisfactory, when events prove one to have been on the right scent, as that of a huge beast which no mortal eye will ever see alive, and which, perhaps, none ever did behold!

Such a chase is not ended in a day, a week, or a season. One's interest is revived and roused year by year as bit by bit of the petrified portions of the skeleton come to hand, and thirty such years elapsed ere I was able to outline a restoration of *Diprotodon australis* such as is shown in the plate of the work† now submitted to the Institute.

The dental formula of the *Diprotodon* is that of the notothere and of the kangaroo, namely, $i\frac{3-3}{1-1}$, $c\frac{0-0}{0-0}$, $m\frac{5-5}{5-5}$, $= 28$. The true molars have the crown cleft into two strong transverse ridges, also the fundamental pattern of those teeth in the kangaroos. But the skull of the *Diprotodon* is a yard in length.‡ The thigh-bone might well suggest to the Parisian palæontologist the idea of an elephantine quadruped. The fore limbs and hind limbs are of equal length. The animal must

* See Lyell, "Principles of Geology," 8vo. ed. 1835, p. 143.

† "Researches on the Fossil Remains of the Extinct Mammals of Australia: with a Notice of the Extinct Marsupials of England." 4to. 2 vols. 1877. (Erxleben, 2 Henrietta Street, Brunswick Square.)

‡ See Frontispiece of the above work.

have trod the ground like a heavy pachydermal brute. Yet there are multiplied proofs in its skeleton that it carried its young in a pouch, and that it belonged to the prevalent characteristic type of suckling beasts in Australia—that it was, in fact, the giant of the Marsupial order.

In wild nature a balance is maintained between the flesh-makers and the flesh-eaters. The teleologist expatiates upon the beneficence of the check interposed by Providence upon the undue increase of the vegetable feeders through the contemporaneous existence of their devourers.* In Australia, at the present period, the wild or native browsers and grazers are in excess.

The native or aboriginal carnivora are now too few and too feeble to keep the herds of kangaroos in due check. The largest known existing native carnivore in Australia is the so-called "native cat" (*Dasyurus macrurus*).

In the smaller adjacent insular tract of "Van Diemen's Land," or Tasmania, although there be no kangaroo exceeding the Australian rufous kind in size, there are two kinds of indigenous Marsupial carnivora larger and more destructive than any known to exist in the more extensive continent. One of these is the so-called "Devil," the other the native hyæna. The zoologist substitutes for the colonial vernacular appellatives his descriptive Greek compounds. *Sarcophilus*, or "flesh-lover," designates the mischievous, untamable brute which might weigh down a jackal, though of more compact and robust build; *Thylacinus*, or "pouched wolf," or "hyæna," is the name by which the larger striped sheep-worrier is known to science.

Strange that neither of these "checks" should exist in the wider field, to operate upon the manifold herds of marsupial herbivores of the larger continent! Stranger still if the balance or check had never been interposed during the old times, when the larger kinds of kangaroo and their huge, even gigantic, congeners browsed the scrub or grazed the prairie over the length and breadth of the Australian continent.

The following is the account which the palæontologist has to render on this subject. Mitchell's gatherings in the breccia clefts and hollows of the limestone rocks in Eastern Australia included remains of both *Sarcophilus* and *Thylacinus*, corresponding in bulk and specific characters with the species still existing in Tasmania. Considering the size of these carnivores, their audacity, the damage which the larger one inflicts upon the flocks of the Tasmanian colonist, and the stupid pertinacity with which the smaller "devil" devastates

* Buckland, "Bridgewater Treatise," vol. i.

his poultry-yard, it is not likely that either species would have escaped the notice of the Australian settler if it had lingered on to be a pest, or an ally, to any of the great Colonies of that continent.

I conclude, therefore, that both the species have become extinct in Australia, and that they formerly existed there as they still exist in Tasmania. Moreover, in addition to the cave specimens, I have received evidences of both *Thylacinus* and *Sarcophilus* from the drift deposits and beds of rivers in several and distant parts of Australia. And these fossils, besides testifying to species undistinguishable by tooth and bone from the Tasmanian kinds, indicate others of larger size, which have never been observed living. Of *Sarcophilus*, of which the present ursine kind might be matched by a jackal, I have had evidence of a species (*Sarcophilus laniarius*) as big as a leopard. Of *Thylacinus* I have also fossils of a larger than the existing kind, equalling a panther in power (*Thylacinus major*). Neither of these extinct Australian carnivores, however, bore the proportion to the nototheres and diprotodons which the South African lion bears to the buffaloes, elands, and other great herbivores upon which it preys.

Something still seemed wanting in the proportion of the beasts of prey to the beasts which converted the grass and herbage of the field into flesh in these ancient epochs of Australian life.

Now, among the fossils submitted to me by Major Mitchell, in 1835, was a tooth which, from its resemblance to that called the "carnassial" or "flesh-cutter" in the lion's jaw, raised a suspicion that there had existed in Australia a carnivore exceeding in size the largest of the extinct Thylacines. But a comparison of this solitary fossil with all the modifications of the teeth in the various existing kinds of Marsupialia, had made me acquainted with a somewhat similarly shaped sectorial tooth in certain small phytophagous and mixed-feeding genera. I could not, therefore, give undue weight to other resemblances supporting only a conjecture. Additional discoveries might supply the required test, and were to be waited for. If the large fossil sectorial tooth in question was the premolar of a gigantic phalanger or potoroo, it must have been preceded by teeth shaped for cutting and nibbling, and have been followed by several large flat or ridged broad molars for crushing and grinding. If the large sectorial tooth was a premolar of a carnivore, it must have been preceded by teeth for piercing and holding, and have been followed by molars small in size and few in number, tubercular in shape, and adapted at best for pounding gristle or tendon.

Pending, therefore, the possible acquisition of specimens

yielding the required dental evidence, I contented myself with giving figures of the tooth in question,* in order to attract attention to any fossils which might show such a tooth associated with more of the animal's dentition.

In the course of a few years I received the requisite evidence. First, in the form of a lower jaw, from the bed of the Condamine River, Queensland; next, in that of a mutilated skull, from the bed of a lake eighty miles south-west of Melbourne; and subsequently, by more perfect specimens demonstrative of the super-carnivorous character of the dentition of the extinct beast, which thereupon I called *Thylacoleo*, or pouched lion. Teeth like the canine tusks of the lion precede the carnassial tooth first discovered; that tooth is followed, also as in the lion, by one small tubercular tooth in the upper jaw, opposed to two smaller tuberculars in the lower jaw; the carnassial of that jaw worked upon the upper one like a shear-blade, and the extensive and smoothly worn surfaces are matched by those of the flesh-cutters in old lions and hyænas of the present day.

Thus it appears that Australia was formerly inhabited by mammals of the peculiar marsupial type, not only varied for predatory and herb-eating life, but exhibiting their type under dimensions as varied as are the higher or placental wild beasts of the larger continents of the globe. Creatures nearest of kin to the Australian forms, and, like them, marsupial, have indeed lived and bred on land which now forms part of the island of Great Britain. Fossil remains of a carnivorous mammal with a dentition most nearly like that of *Thylacoleo*, have been discovered at Purbeck, on the Dorsetshire coast. Fossil remains of an insectivorous marsupial, many-toothed like the Australian *Myrmecobius*, have been found in Oxfordshire, in the slates of Stonesfield. Both these localities are of the middle or "Mesozoic" period in geology, and I may give an idea of their antiquity by saying that not a particle of the chalk cliffs or "bushless downs" in England had been formed when the old pre-Britannic continent flourished which, in its vegetation, its shells, the fishes of its sea-shore, and the beasts of its fields, bore the nearest resemblance, in fauna and flora, to the antipodean seat of our present flourishing Australian Colonies. We are now superseding there the Oolitic types, which alone presented themselves to the naturalists of Cook's voyage, by the higher forms of vegetable and animal life that have lent themselves, or been by man adapted, to his special needs in Asia and Europe.

But the kangaroo, which Banks and Solander first saw, and thought to be a huge bird as it hopped out of their ken into the

* Plate xxxii., figs. 10 and 11, of Appendix to the "Three Expeditions," &c. 8vo. 1838.

scrub, was actually the largest marsupial quadruped that at that date existed in Australia.

At what period became extinct those huger forms of marsupial life which palæontology has made known to us? To what cause is due the extinction in Australia of the diprotodons, the nototheres, the thylacoleons, the phascolones or gigantic wombats, the palorchestes, procoptodonts, protemnodonts, sthenurans, with the thylacines and sarcophiles which alone of all the preceding marsupials still linger on in life in the neighbouring island of Tasmania?

No other extirpating cause has suggested itself to my mind save the hostile agency of man. No evidence of diluvial catastrophe or of climatal change has been discovered to account for the disappearance, for example, of the *Macropus Titan* and the survival of *Macropus major*.

To a race of men depending, like the "black fellows," for subsistence on the chase, the largest and most conspicuous kinds of wild beast first fall a prey. The smaller kinds, with swifter powers of locomotion, more easily conceal themselves and escape.

True it is that, as yet, no evidence of the ancestry of the existing aborigines of Australia has been detected in the caverns which have yielded fossil remains of their hypothetical prey. But such caves, if explored with due care, skill, and method, may bring to light, as they have done in England, indubitable evidences of the pre-Adamatic or pre-historic men of Australia; the extensive shell-mounds attest the enormous period during which these primitive people roamed over that continent.*

In conclusion, I may remark that at the commencement of my application of anatomical knowledge, fifty years ago, to the reconstruction of extinct species, not one of the classes here treated of was known to have lived in any of the three great Colonies which I have selected for this evening's discourse.

What, then, may be expected from analogous researches and collections of the fossil remains in the caves, drifts, and tertiary deposits of New Guinea? As we learnt from the admirable Paper to which I was privileged to listen at a former meeting of this Institute, we may infer from the varied configuration of New Guinea, from its mountain ranges and concomitant streams and rivers, its caverns, doubtless opening into defiles and valleys, its latitudes, involving conditions and stimulants of life surpassing those under which the beasts flourished on whose remains Colonial palæontology has been hitherto exercised, that there is

* In 1869 the Parliament of New South Wales voted the sum of 200*l.* in aid "of a careful and systematic Exploration of the Limestone Caves of Wellington Valley."

a promise of results which will exceed in novelty, in singularity, and variety of vertebrate structures all that has been contributed from Australia and New Zealand towards a philosophical comprehension of the scheme and origin and progress of animated nature.

IS NEST-BUILDING AN INSTINCT IN BIRDS?

By BENJAMIN T. LOWNE, F.L.S.

MR. ALFRED R. WALLACE, in his contributions to the theory of natural selection, has an essay on the philosophy of birds' nests, in which he controverts the doctrine, which he admits to be almost universally held, that birds build their nests by instinct; and he believes that both birds and men, in a primitive state, build by imitation. He says, "It will be objected, that birds do not learn to make their nests as man does to build, for all birds will make exactly the same nest as the rest of their species, even if they have never seen one, and it is instinct alone that can enable them to do this. No doubt this would be instinct, if it were true, and I simply ask for proof of the fact; this point, although so important to the question at issue, is always assumed without proof, and even against proof, for what facts there are are opposed to it. Birds brought up from the egg in cages do not make the characteristic nest of their species, even though the proper materials are supplied to them, and often make no nest at all; but rudely heap together a quantity of materials: and the experiment has never been fairly tried of turning out a pair of birds so brought up into an enclosure, covered with netting, and watching the result of their untaught attempts at nest making."

I have lately had the opportunity of making the experiment, which Mr. Wallace states has never been fairly made; and much to my surprise, for a year ago I fully believed Mr. Wallace was right, the results are at complete variance with the opinion which Mr. Wallace has promulgated upon this subject. I will give the details of my experiment in full, reserving all comment until I have done so.

Last spring I received a pair of young ring-doves (*Columba risoria*), in their first plumage, which had been hatched in the breeding-box of an ordinary dove's cage, upon a straw nest built on the floor of the cage. These were a male and a female; but at the time I received them they were so young that I came to

the conclusion, from their very quarrelsome habits, that they were of the same sex; in consequence of this opinion, which I afterwards found to be erroneous, I asked the lady who gave me the first pair to give me another young dove. She gave me one brought up in the same manner. I kept these three doves in a wire cage until this spring. The exact size of the cage was three feet by two, and two feet high. They turned out to be a cock and two hens. At the end of February each hen laid two eggs on a bundle of hay placed in one corner of the cage; but there was not the slightest attempt at nest-building, although they played with the hay, carrying about a piece in their bills by the hour together. The females sat by turns with the male, and in due time three of the eggs hatched. Although some interesting facts were brought to light in the rearing of these young birds, it suffices to observe in the present connection, that only one of the young birds became fully fledged, the others died from heartless neglect on the part of the parents, apparently because they were feeble and two days younger than the chick that was reared.

In the middle of April I turned the three birds out into an aviary in the open air, in which there was a large branch of a tree with numerous twigs and buds to serve as a perch. The highest branchlets of this were about nine feet from the ground.

I provided the birds with a double breeding-box, similar to the one in which they were themselves hatched, in one side of this I placed a handful of hay, together with their newly fledged offspring. I left the other side empty, in the expectation that they might possibly build a nest of hay or straw, and I supplied them with both materials. The young dove learned to fly in a few days, and slept in its box at night, its parents and foster-mother fed it continually in the nest-box; but there was no attempt to make another nest in the box.

About a week after I placed the birds in the new aviary they took possession of the highest twigs of the tree branch, each with a small piece of stick in its bill; as I judged they intended to build in this portion of the tree, I at once supplied them with a number of twigs; these were nearly all straight twigs of varying length and thickness, without any lateral branches; but amongst them were a few pieces, each with a short lateral branch, which were at once collected by the doves, and carried to the place they had selected for their nest; but they evidently had not the slightest idea of the use of the sticks they had selected. They tried in vain to fix them to the wall of the aviary or to its roof, almost always to the latter, and waved them about above their heads until they dropped them. I thought that they might be in the habit, in nature, of laying the foundations of their nest in twigs above their heads, so I fixed some perches below the cleft

in the tree which I thought they had selected to build in, and wove two or three small branches in such a manner as to afford them a choice of resting-place, and also to catch the sticks they dropped. I ought to have mentioned, that the birds were excessively tame, having been brought up in the house, and that I was constantly in the habit of taking them from their cage and playing with them, hence they allowed me to stroke them or handle them without fear, so that my interference did not disturb them. As soon as I had finished, the male bird found the new place, and cooed in evident delight, and he was immediately joined by the two hens, each with a stick.

After vainly endeavouring to lodge the sticks above their heads for a couple of hours, sometimes from the old and sometimes from the new resting-place, and dropping them, they gave up work.

I now, however, observed that all the cleft and branched sticks had been gathered from the bottom of the aviary and lodged amongst the branches near the top of the tree. I also observed that the birds every now and then picked up a stick, balanced it for a little time in their bills, and then dropped it again. The thought struck me that straight sticks and twigs would not do, so I collected a number of forked branches and branches with lateral twigs. No sooner were these thrown into the cage, than the birds made their usual crowing noise and resumed work. As soon as all the branched sticks were used, they at once ceased work, although there was an abundance of unbranched sticks of suitable size in the cage. The end of all this was, that in three days, they had finished a nest exactly like that of a wood pigeon. They lined it neatly with straw, and ornamented it with some tufts of the dried flowers of the sugar-cane (*Saccharum officinale*), which I took out of a vase in the drawing-room, and broke up, as I thought the soft feather-like flowers of the grass would make a good lining to the nest. They did not use it, however, for this purpose, but let a few pieces hang over the edge of the nest, with a great deal of straw, perhaps for the purpose of concealment. Each dove laid two eggs in the nest, and they are now sitting by turns with the male.

The apparent use of the side branches on the twigs which they use is to peg the nest together, as these hang down and pass through the meshes of the sticks which are already laid.

The important facts to my mind are, first, these birds had never seen a tree, or, at least, sat on one, yet they selected a place nine feet from the ground for their nest. They had never seen twigs, and could have no experience in the use of lateral branches, yet they carefully selected these and no other. Secondly, they had apparently no idea of the use to put the sticks to, when they had selected them, unless they are in the

habit, in a state of nature, of starting the nest on branches above their heads. As soon, however, as a few branches had lodged below them, they finished the nest, which accident had commenced for them. Thirdly, they followed the habits of the species to which they belong, although it is probable that these habits had been in abeyance for many generations, and certainly they had been in abeyance for more than one generation. Fourthly, the conditions were present which would have enabled them to breed in the same kind of nest as that in which they were themselves brought up, and in which they had already reared a young bird. Lastly, these birds were very tame, so that if new conditions could have modified their natural habits, this was a case in which we might have expected modification, as all the circumstances were in favour of a perversion of natural habits.

I do not know how to account for the fact that these birds built a natural nest. And I may be hasty in my conclusion, but I am in my own mind convinced that we have here an instance of what is usually called Instinct. This conviction is the more important because it is not a year ago since I gave a lecture in Great Ormond Street, at the Working Men's College, in which I maintained the view that animals act in such cases entirely by reason and experience; and at that time I felt certain from all I knew that Mr. Wallace was right, or nearly right, in his views.

The whole phenomenon had a striking similarity to the slow return of memory, brought about by a series of associations. There can be no doubt as long as the birds remained in a comparatively confined space, without the use of their wings, and without a natural branching tree to build in, they would never have built a characteristic nest. My own belief is, that the tree acted as a stimulus to their instinct, and that the natural surroundings prompted them, as it were, and awakened their dormant inherited powers. Although my impression is, that the final site of the nest was determined by the place where the sticks fell, which they failed to fix above them, I am by no means assured in my own mind that even this was not determined by a subsequent awakening of an instinctive act, and that the sticks were intentionally dropped upon the branch below them. The want of readiness in some things which these birds exhibited at first can hardly be considered surprising, when we remember the number of generations in which it is probable no natural nest had been built. Indeed, it is quite possible, and I think even probable, that their progenitors had laid their eggs on hay or straw on the floor of a dove-cot for fifty years or longer.

The importance of these facts can hardly be over estimated,

as they bear upon the theory of innate ideas, or at least of innate genius. From the foregoing experiment the conclusion is very tempting, that the birds are endowed with special faculties and ideas, just as it appears that men are born with a special aptitude for certain acts, both mental and physical, and that mind is endowed with properties of a special nature; at least, they are of great interest because they are facts which ought not to happen, according to the theory which is daily becoming more fully received. They belong to one of those by-paths of Biology, which it is Mr. Wallace's delight to tread, and in which he has done such excellent work.

Fig. 1. *Section from the South Downs to the No*

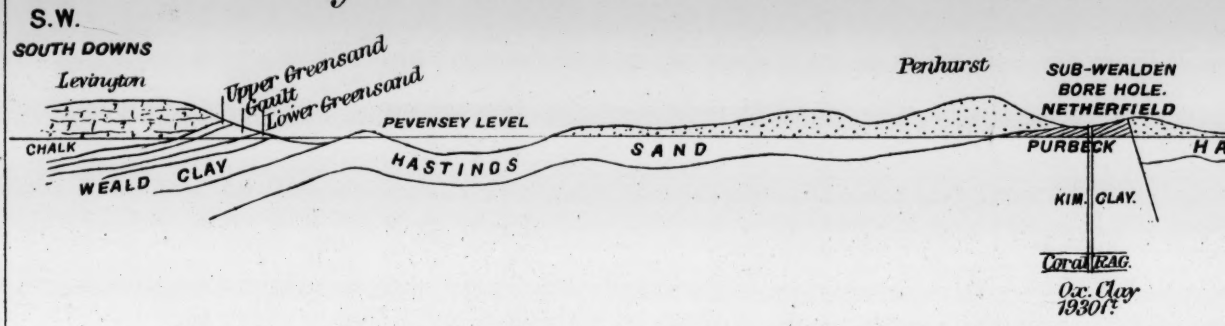


Fig. 2. *Section from Reigate to Coxton through London, showing the th*

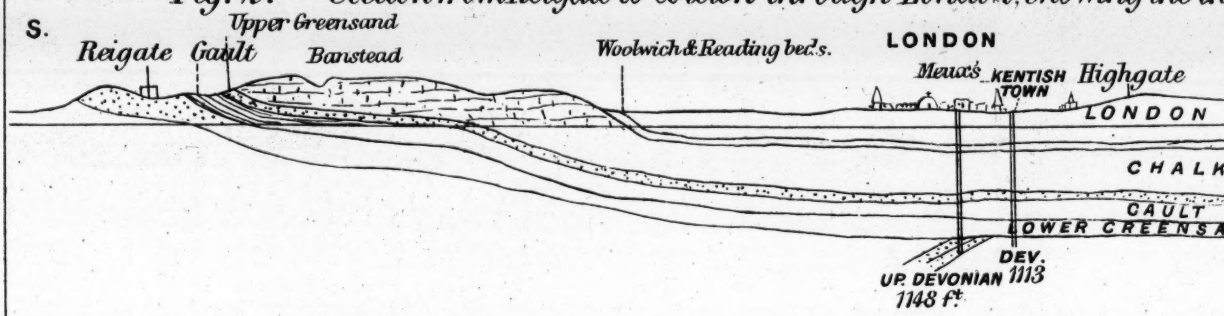
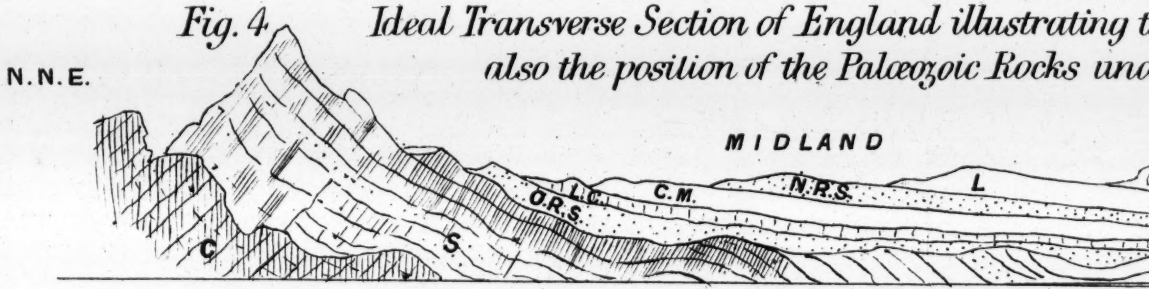


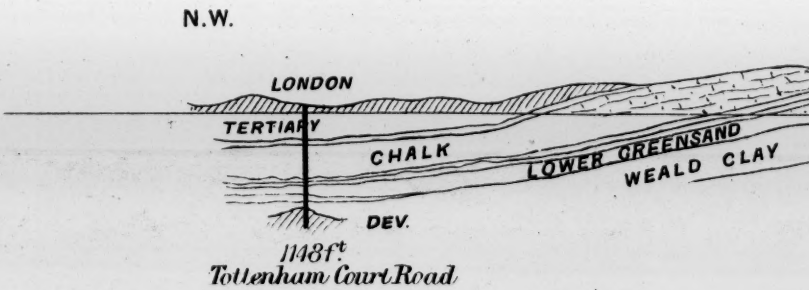
Fig. 4 *Ideal Transverse Section of England illustrating t*
also the position of the Palæozoic Rocks und



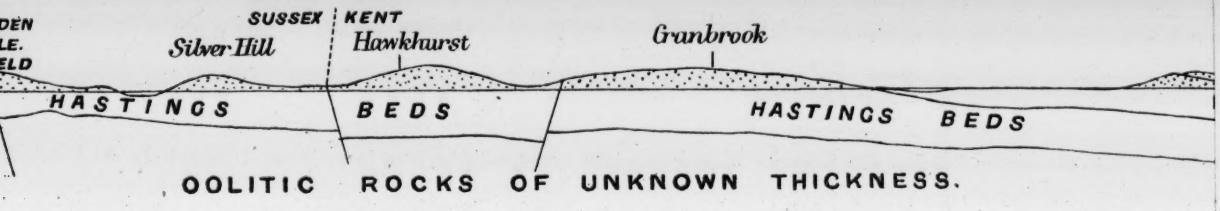
CAMBRIAN and SILURIAN ROCKS forming the foundation for

C.	Cambrian.	C.L.	Carbonif
S.	Silurian	N.R.S.	New Red
O.R.S.	Old Red Sandstone & Devonian.	L.	Lias.

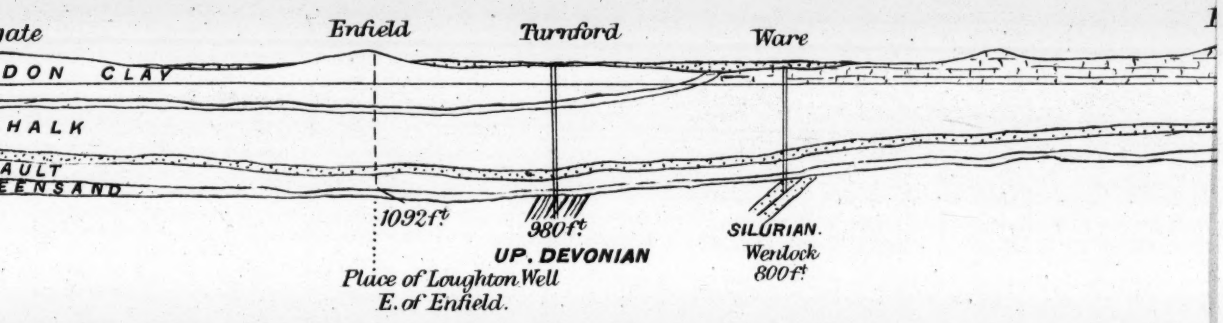
Fig. 3. *Section from London to St. Leonards through*



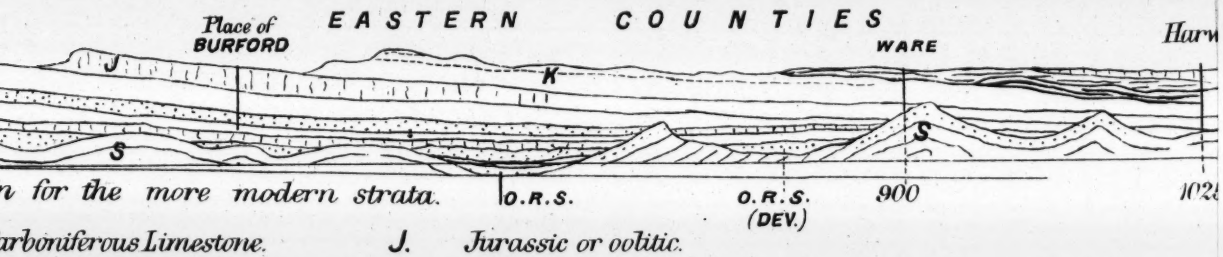
ne North Downs through the Sub-Wealden bore hole. W. Topley F.G.S



the three borings, Meux's, (Tottenham Court Road) Turnford, and Ware, after Pr



ting the S.E. attenuation of the older Mesozoic formations
s under the Eastern Counties. after Professor Hull (Coal fields of Great Britain



n for the more modern strata.

arboniferous Limestone.	J.	*Jurassic or oolitic.*
lew Red Sandstone.	K.	*Chalk.*
ias.	L.	*Tertiary.*

ough Tottenham Court Road, and the Sub-Wealden boring. W. Topley F.G.S.

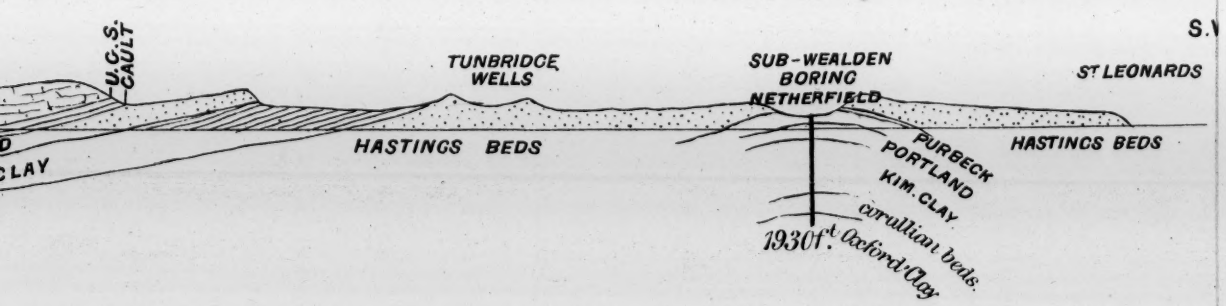
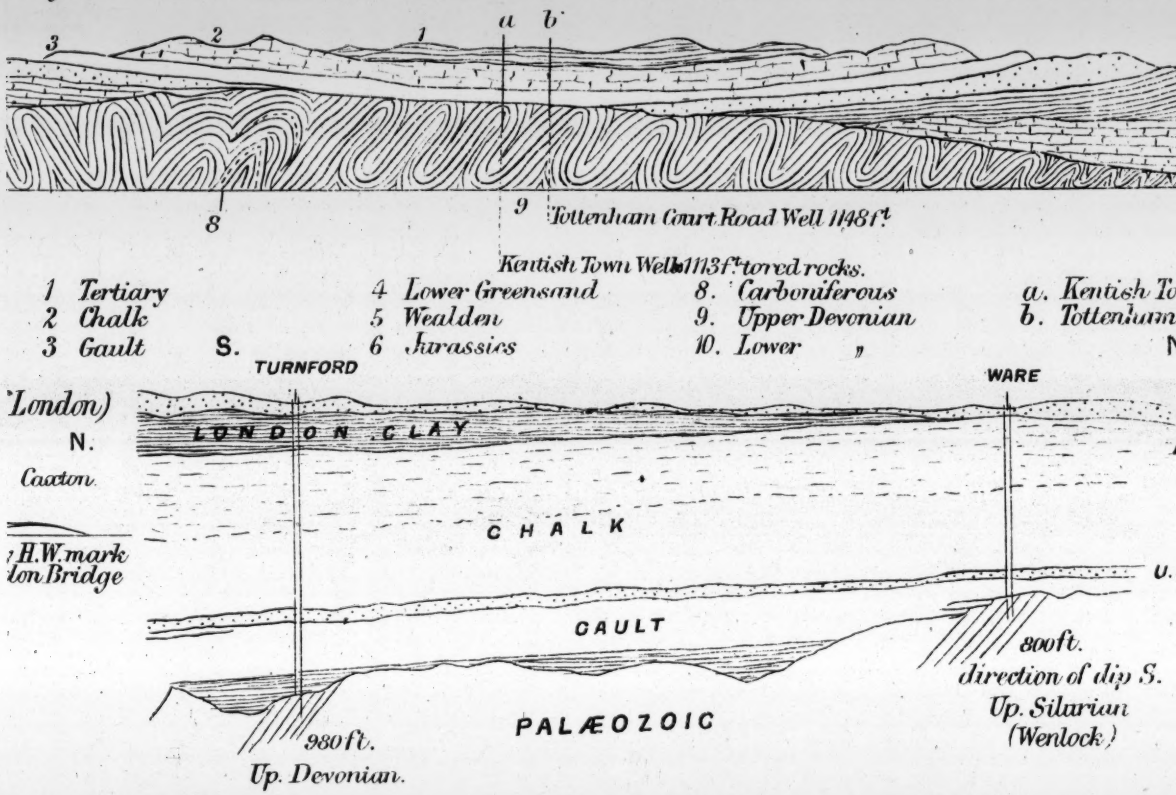


Diagram Section from the North Downs to London. Prof. Prestwich Q.J.G.Soc. Vol. 34.



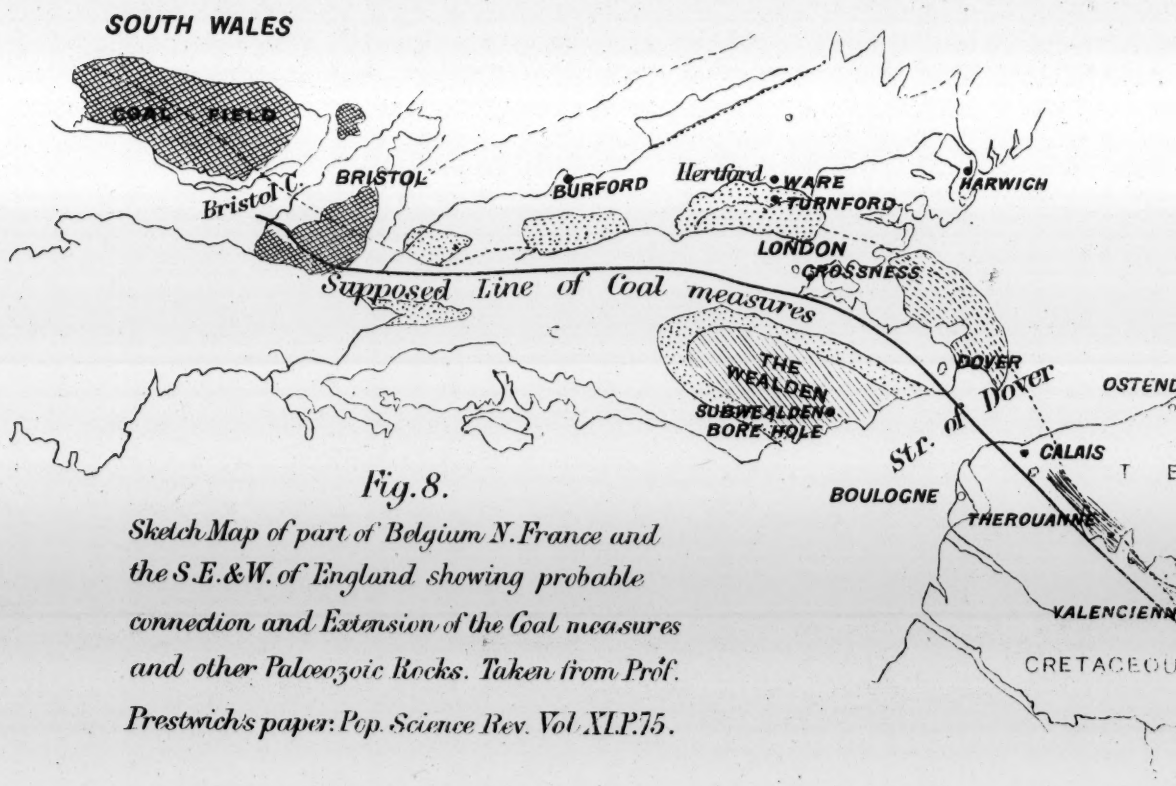


Fig. 8.

Sketch Map of part of Belgium N. France and the S.E. & W. of England showing probable connection and Extension of the Coal measures and other Palæozoic Rocks. Taken from Prof. Prestwich's paper: Pop. Science Rev. Vol. XLP.75.

l. 34.

S.

ntish Town Well
lenham Court Road „
N.

Fig. 6.

U.C.S.

dip S.
ian
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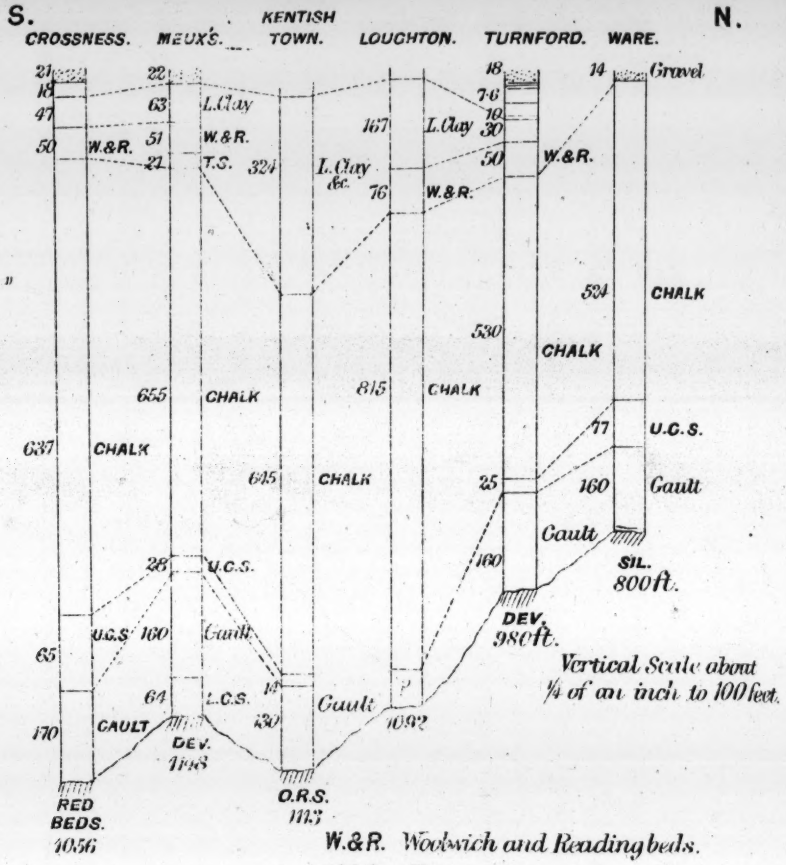
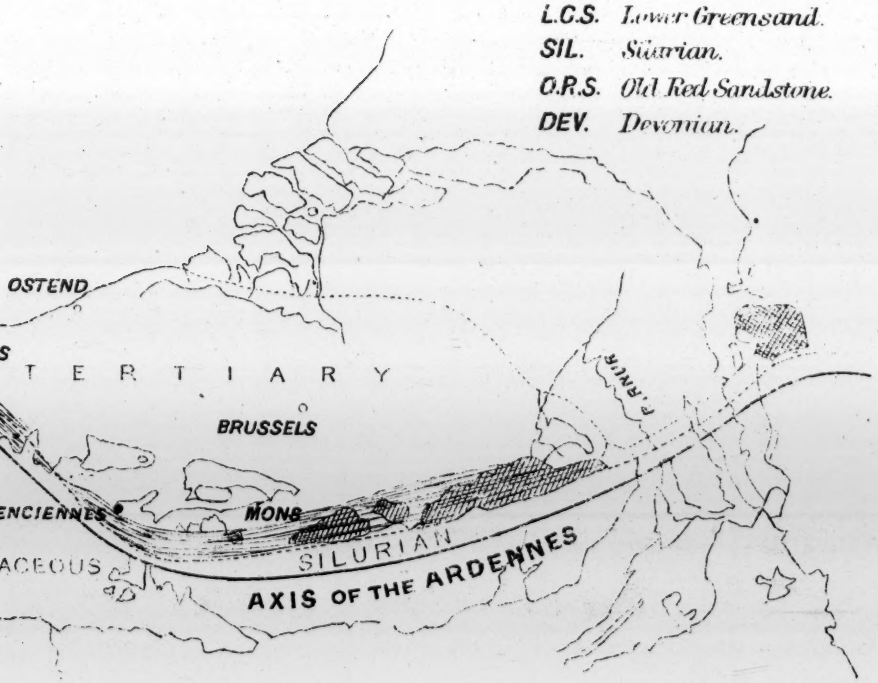
Fig. 7. *Comparative Sections of the Tertiary & Chalk rocks as shewn in the 6 borings from Ware to Crossness or from N. to S.*



W.&R. *Woolwich and Reading beds.*
U.C.S. *Upper Greensand.*
L.C.S. *Lower Greensand.*
SIL. *Silurian.*
O.R.S. *Old Red Sandstone.*
DEV. *Devonian.*



DANGERFIELD. LITH. 22. BEDFORD ST. COVENT GARDEN.

THE POSITION OF THE SILURIAN, DEVONIAN, AND CARBONIFEROUS ROCKS IN THE LONDON AREA.

By Robert Etheridge, F.R.S., etc.

[PLATE VII.]

As long ago as 1856 a distinguished author and physicist communicated to the Geological Society a remarkable paper upon "The possible extension of the Coal-Measures beneath the south-eastern part of England."* Speculative as those views and generalizations then seemed to be, they but foreshadowed, and almost foretold, what of late has been to a great extent realized.

Competent geologists were then appealed to, to admit the broad generalizations put forth as to the extension from the Continent (Belgium and France) of the older rocks (Coal-Measures) beneath the superincumbent strata of London Clay, Chalk, Gault, Lower Greensand, and Wealden, in the south-east of England generally.

This problem was then, as now, of national importance, and gave rise to much speculation as to the continuity of certain formations or rock masses occurring beneath the German Ocean, from the Belgian and German areas, and also under the English Channel from the north-east of France. Although Mr. Austen's paper bore the title of the "Possible extension of the Coal-Measures beneath the south-eastern part of England," it had a far wider and greater significance than at first sight appears, it being certain that with the occurrence of any such extension of the Carboniferous rocks from Western Europe we should expect still older Palæozoic rocks to be more or less associated with them. This now turns out to be true, so far as the two older groups, the Devonian and Silurian, are concerned; the Devonian occurring immediately beneath the Cretaceous group in London, and eighteen miles north of it, at Turnford, near Cheshunt; the other, the Wenlock Shale (Upper Silurian), having lately been determined at Ware, immediately below the Gault, and penetrated about 25 feet. No less than thirty species of fossils have been determined from the cores brought up.

* R. Godwin-Austen, Esq., "Quart. Journ. Geol. Soc." vol. xii. pp. 38–46.

Looking at the physical structure of the south-western and north-western part of England, and the great mass of the older Palæozoic rocks of North and South Wales, it is evident that from the Cheviots to Cornwall the oldest rocks in Europe are exposed, hidden only in places by a mantle of superficial glacial and river drifts. The eastern sides of the exposed Northumberland and Yorkshire coalfields, down to the latitude of Nottingham, are covered and deeply buried by the Triassic, Jurassic, and Cretaceous rocks; south of Nottingham these old land areas are again exposed. The Charnwood rocks, of *unknown age*, and the associated coalfield of Ashby-de-la-Zouch, with the Warwickshire and South Staffordshire coalfields, stand out like islands in the midst of the great Triassic plain of mid-England; they are the last isolated exposures or remnants of Palæozoic land seen south and east of the great Pennine axis.

The entire mass of North and South Wales stands out in bold relief westwards of the Severn Valley and the stunted hills of Cheshire. The Old Red mountains and Silurian rocks which border the northern edge of the great Welsh coalfield, as well as the Devonian promontory of Cornwall, isolated as they appear to be through the unconformity of the Secondary rocks which constitute the eastern half of England, are only apparently so through this great overlap. Could we uncover and expose the old Palæozoic floor or land surfaces on which they rest, with all its irregularities, doubtless we should find that the eastern face of the Palæozoic plain would stretch away under the north-eastern and south-eastern counties and German Ocean,* filling up the irregularities in the old land surface made either by the denuding agency of the secondary seas during the slow depression of the area they then occupied, or they were previously sculptured and fashioned into hills and valleys at the close of this early period, and prior to the deposition of the Secondary or Mesozoic rocks.

The area on which the British Islands stand is an elevated yet submarine plateau, extending westwards from Ireland some 100 miles, and eastwards to Holland, north to Scandinavia, and southwards to a deep region west of France and Spain. The western face of this plateau, now beneath the sea-level and covered by the Atlantic, has a steep and rapid slope to the profound depths of that ocean. On the eastern side of England, on the other hand, the German Ocean, with its irregularities of sea-bottom, scarcely averages 100 feet in depth, and this shallow sea and the east of England unites us to the European plain. It is upon this plateau that all those changes of level, great and small, change of life,

* See Section No. 4, Pl. VII. Ideal section by Professor Hall, showing the prolongation of the Silurian, Devonian, and Carboniferous rocks eastwards, and the probable irregular surface of the Palæozoic rocks, now covered by nearer deposits. ("Coal-fields of Great Britain," p. 475).

or change of fauna—indeed, all the physical history of the British Archipelago—have taken place, on which have been modified the shape, size, and life history of the British Islands through all time, and by it we have been united countless times to the continent of Europe and probably to America. The Irish Sea and German Ocean or North Sea, and English Channel are now the one a shallow the other a deep hollow in the land, filled by the waters of the great Atlantic to the west, their beds being only a question of level.

An elevation of the bed of the German Ocean, or that part of the plateau, 100 feet, would unite us again to Europe; and some 300 or 400 feet would unite England to Ireland, and less than half that to France. A depression of one-eighth of a mile, or 600 feet, would render us an extensive archipelago, when nearly all the centre of England would be submerged. The Welsh and Cumbrian mountains, the Pennine chain, much of Scotland, and the bold coast-line of Ireland, would stand out as islands. The Hebrides, Shetland Isles, and those off the west coast of Scotland, are only outliers of the main land, evidences of change, mountains in the sea; the valleys being pasture land and feeding ground for dwellers in the ocean, nurseries for the fauna and flora of the sea, yet if the bed of the North Atlantic area were elevated but a comparatively few fathoms they would no longer be islands. It was upon this British and European plateau, then a land surface, that our coal growths and coalfields had their origin, growth, and development, stretching far away to the eastward in Europe, to Mons and Liége, and onwards as far as Westphalia, doubtless as one continuous terrestrial surface. Movements or oscillations of level through depressions and elevations greater than the present depth of the Atlantic, did then and have since repeatedly occurred, and most if not all the phases in the physical history of the British Islands have been governed and modified upon this area between the 500 fathom level off the western coast of Ireland and the flats of Holland and Belgium.

Such changes are still in action although slow. Unceasingly they go on, time only being required to do again all that had been done before. The sea, with its tides and ceaseless action, is both destroyer and preserver; it carves and denudes coast lines into shape, modifies sea bottoms, and, aided on the land by meteoric action through the agencies of rain, frost, ice, wind, and sunshine, fashions into contour the form of the mountain, curves of the valley, and depth of the gorge. The creeks of the Australian and cañons of the American are but terms for phenomena produced by rain and river action governed by time.

The above generalizations tend to lead us to the physiography of the older continents and areas, or those of Palæozoic and

Mesozoic times, to be determined and understood only through the application of modern laws, or as read by recent physical geography, which applied to the past enables us to read with tolerable accuracy, even at great depths, the configuration and condition of those areas once at or near the surface, but now deeply hidden, and revealed again in part through the application of the boring-tool in our search either for water or for mineral wealth.

As far back as 1856, Mr. Godwin-Austen almost asked for a practical solution of his views. "What is now," he says, "above measure needed is, that we should *obtain one single point of verification as to the depth at which any part of the Palæozoic group occurs beneath our south-east area.* The state of the question is such, that from this one single point, once ascertained, the rest of the investigation might be conducted, for practical purposes, with perfect certainty, and it is therefore of importance that the question and its possible results should not be lost sight of by all those who may be promoting deep sinkings at any places over the area which has been here indicated."

Again, Mr. Prestwich, in 1872, in his admirable article "On the probable existence of coal measures in the south-east of England," * speaks regrettingly of the fact that up to that time, "in this country, the newer strata overlying the Palæozoic range have been sunk into without result in the Wealden at Hastings to a depth of 486 feet; at Earlswood, near Reigate, in the same strata, to about 900 feet; through the chalk at Chichester to 945 feet; and at Southampton through tertiary strata and chalk to a depth of 1,317 feet. Unfortunately, all these works fall short of the mark which geologists wish to attain."

In continuation Mr. Prestwich remarks 'that in an industrial point of view no experiments could be more important than such as would serve to determine the position of this great underground range of older rocks, connecting the Ardennes and the Mendips. We have ascertained that it lies at no great depth beneath the overlying newer strata, and if the strike of the line of disturbance were in a straight line we should have no difficulty in determining its course.' Local deflection may have affected its east and west bearings through its range of 800 miles; and, "whilst Mr. Godwin-Austen would place the supposed coal trough in the Valley of the Thames, or under the North Downs," Mr. Prestwich would prefer placing it further north, in Essex or Hertfordshire; and whilst also Mr. Austen believed it to be continuous or extended, Mr. Prestwich favoured the idea that it is probably broken up into basins. "If, however," he says, "the axis of the Ardennes consisted of an anticlinal line,

* Popular Science Review, vol. xi. p. 241. 1872.

the problem would be simplified, but it consists of a series of such parallel lines, and therefore whether or not the one which traverses the Boulonnais, and is probably prolonged under our Wealden area, is one of the many central ones, or the lateral one, immediately flanking the coal trough, is uncertain. Any attempt made to solve this great problem must be hailed with satisfaction; but it is not by one experiment, however, but rather by several, that the line of the great trough of productive coal measures will be determined."

These petitions to practical science, aided by capital and necessity, have at last partly helped to solve the long-discussed problem, and we now have four if not five well-determined sites within the London area where the Palæozoic rocks have been definitely touched. They are Tottenham Court Road, Ware, Turnford, Crossness, Kentish Town, and another distant but equally important trial at Burford, where the coal measures were satisfactorily proved.*

Old British Terrestrial Surfaces or Areas.

There seems to be good reason for believing that a once continuous north and south range of older Palæozoic land extended from the Polar regions to the Mediterranean. The only portion remaining entire is the Scandinavian peninsula, ranging through about 15° of latitude; it is known "beneath newer and overlying deposits of Northern Germany, the Vosgean and Schwarzwald ranges, and expands into the elevated plateau of Central France."

Mr. Godwin-Austen believes it to be traceable to the islands of Corsica and Sardinia, north of the African coast.

Westward of this another mass of old land occurred "to the north-west of the British Islands, and probably in its range formed the western boundary of the great European basin." The sources of these oldest sedimentary strata will ever remain a mystery; such are now either concealed beneath the Atlantic, through depression, or entirely removed through denudation. "The *materials* that supplied these oldest British strata have wholly disappeared," for doubtless the stratigraphical arrangements of these early deposits was in subordination to masses removed, and "the extent and dimensions of the Palæozoic masses afford an indication of how vast a region has disappeared." †

* See section from north to south (Sussex to Bedfordshire), across the London Basin (Reigate to Biggleswade), showing the places of the five trials by vertical lines, Pl. VII., sec. 2. The section is copied from Professor Prestwich's work on the water-bearing strata of the country round London.—Pop. Sci. Review, vol. xi. t. 75.

† Vide "Quarterly Journ. Geol. Soc." vol. xii. pp. 42 and 43. (Austen.)

Coal Measures beneath the South-East of England.

The predictions (for such at the time they appeared to be) of Mr. R. A. Godwin-Austen, so far back as 1856, as to the physical condition of the older rocks beneath the south-eastern part of England, and probable extension of the coal measures under the same area, seem now to be almost fulfilled; but as Mr. Austen then stated, "*any restoration of the European surface for this very early period must be purely ideal*," it was to the correct restoration of definite boundaries for areas of land and water in the upper portions of the Palæozoic group that his views and speculations mainly looked for confirmation. Mr. Austen then stated that "those terrestrial masses which are represented *only* by the oldest Palæozoic groups had mostly disappeared;" nevertheless, he says, "we can ascertain something as to their mineral composition and the spaces they occupied, and in this way sketch out the surface of the northern hemisphere under its earliest arrangements."

Of late these far-seeing views and generalizations, and which at first sight seemed problematical, have been singularly realized and verified. Mr. Austen selected for his theme the intricate question of the "probable extension of the coal measures beneath the south-eastern part of England." By this he not only attempted to trace the terrestrial surface on which the old British coal forests stood, and their probable range and area, but carried his researches into western Europe, from Valenciennes to the valley of the Ruhr, east of the Ardennes, a distance of 170 miles, and then on to Westphalia. Along this great coalfield numerous trial-shafts have indicated its probable extension and continuity.

The Valenciennes coalfield is known to extend and has been proved 80 miles west of Valenciennes by Douay, Bethune, and St. Omer, and worked beneath the Chalk of the north of France.

The Palæozoic rocks of the Boulonnais have been revealed below the cretaceous series at Guines at a depth of 800 feet, and consisted of sandstones and shales; and as will be seen hereafter, the Silurian rocks below, of older date still, were touched by the boring-tool at the same depth at Calais, and at a depth of 1,100 feet, and below the chalk the true Coal-measures were determined.

The determination or recognition of the presence of the Coal-measures (Upper Palæozoic rocks) in the north coast of France, their undoubted connection with and prolongation from the Belgian area, led to the views then enunciated by Mr. Godwin-Austen as to the "amount of evidence (*à priori*) as to whether the coal series may be continued further west across the Straits of Dover and so beneath our south-eastern counties," and

"whether, if so, the coal measures were likely to occur under such condition of depth with respect to the overlying formation as would render them available to us."*

It was not the question of the Coal-measures only being present; on theoretical grounds any other still older sedimentary rocks down to the lowest Cambrian may occur—continuous, either as old land from northern or eastern Europe, or as an easterly prolongation or extension of our north and south Welsh Cambrian or Silurian rocks, rolling away beneath the central, eastern, and southern counties; the floor, indeed, on which stand unconformably all the newer or secondary and tertiary series in their varied features as we now see them.†

It must be borne in mind that in tracing out the physical outlines of western Europe during early times, or its early physiography, Mr. Austen included under the term Carboniferous those rocks, or conditions, whether terrestrial, fresh-water, or marine, from the Marwood and Pilton beds of the Upper Devonian to the top of the Coal-measures or the Upper Palæozoic group. His middle group comprised two series, being equivalent to the Upper Silurian and Devonian, and his Lower Palæozoic group embraced all the marine sedimentary strata up to the Lower Silurian inclusive; it is important to define the classification then used by Mr. Austen, and also in subsequent research and literature.

Mr. Godwin-Austen‡ showed that the coal measures which thin away under the chalk near Thérouanne probably set in again near Calais, and are prolonged (beneath the Tertiary and Chalk strata) in the line of the Thames Valley parallel with the North Downs, and continue thence under the valley of the Kennet into or towards the Bath and Bristol coal area. On theoretical grounds, carefully thought out, he concluded that the Coal-measures of much of England, France, and Belgium were probably once continuous, and that the present coalfields were merely fragments of one great original deposit which he inferred had been broken up in two directions, but prior to the deposition of the now overlying secondary rocks. This line of disturbance trended generally in an east and west direction, and part of it formed the anticlinal of the Ardennes, by which the Belgian coalfield had been brought to the surface; and the Mendip Hills with the Somerset coalfield are also on that same

* "Quarterly Journ. Geolog. Soc." vol. xii. *loc. cit.*, and vide Plate VII. fig. 8 map showing the continuity and probable extension of the Belgian coal-measures under the Straits of Dover and the Wealden area, etc., and on to the Mendip Hills and South Wales. (Copied from Professor Prestwich's paper, POP. SCI. REVIEW, vol. xi.).

† Vide Section 4, pl. VII.

‡ "Quarterly Journ. Geol. Soc." vol. xii. 1875.

line of strike. The Belgian coal-field is but one of a deep, long and narrow series, ranging from Westphalia to the north of France. The most easterly is that of the Ruhr, the second Aix-la-Chapelle, the third Liége, and the fourth Hainault and Valenciennes; it is then probably hidden on its north-westerly strike from Thérouanne by the newer rocks, and its extension is proved by boring at Calais; the main axis (that of Ardennes) crossing the Straits of Dover, passing, as before stated, south of London through Berks, Wilts, and into Somersetshire, there to join the Mendip disturbances, and on to the southern edge of the great and exposed Welsh coalfield, by Worm's Head, Tenby, and St. David's, determining and probably defining the boundary between the Marine Devonians on the south of the Mendip and Ardennes axis, from that of the Old Red Sandstone north of it, and the great Hereford and Brecknock Old Red north-west of the Severn.* In 1872 Professor Prestwich wrote his most able paper in the "Popular Science Review" (*loc. cit.*), stating therein (p. 235) that "between Clan Down, near Bath, and the Well, at Kentish Town, no trial for coal or water had been carried to the base of the secondary rocks or had reached more than about 600 feet beneath the sea level." Since then, not many miles north of the latitude of Bath, the boring at Burford, in Oxfordshire, has passed through the lower secondary rocks and into the Coal-measures, touching them beneath the New Red Sandstone at 1,184 feet. "There can, however," says the learned author, "be little doubt of the continuity of the range of the Palæozoic rocks under these newer formations from Belgium to Somerset; but whether or not the coal measures were ever continuous between the two districts, and whether, if they were, they have been removed by denudation, *leaving only the Lower Palæozoic rocks*, requires further discussion."

Again, Mr. Prestwich, with far-seeing induction (as subsequent investigation has proved in Oxfordshire), discusses the question of the extension of the Bristol coalfield eastwards. This independent basin is cut off both on the east and on the west by ridges of Millstone Grit and Mountain Limestone—the general belief being that the eastern boundary limits the extension; or that eastward of the north and south strike of the edge of the basin there are no more Coal-measures. This eastern edge is covered by the secondary rocks (Trias, Lias, and Oolite), thus causing much uncertainty as to the disposition (or arrangement) of Palæozoic rocks under or east of them.

"Admitting," says Mr. Prestwich, "the basin to be complete and isolated, that is no proof that the older Palæozoic rocks prevail exclusively or come to an end on the east side, for the

* Vide sketch-map No. 8, plate VII.

coal measures of the Somerset basin maintain their full development to the edge of the basin and are then *cut off by denudation* and not brought to an end by thinning out. They form part of a more extended mass of which we have more than one fragment, while on the west another portion exists in the Welsh basin, and another in the newly-discovered small basin of the Severn Valley, *and there is no reason why on the east the same* disposition should *not prevail.*" * These far-seeing views as to the probable physical history of the extended deeply-seated area between Bath and Frome and the German Ocean are being slowly, but I believe surely, verified, and bear entirely upon the researches now being carried on, and upon the palæogeographical distribution of rocks and life over an immense underground tract, and which here and there, by means of the boring-rod, are being tested, and those theoretical views of Mr. Godwin-Austen and Professor Prestwich confirmed.

Although, however, at present no true Coal-measures have been touched or proved along the valley of the Thames, or their extension known to take place from Thérouanne, still the above views, although speculative, have the same value as when first propounded; for although the Devonian rocks have been proved at Tottenham Court Road, and Turnford, six miles south of Ware, it in no way invalidates or does away with the possibility that south of that area or even west of London the Coal-measures may occur. The failure of the sub-Wealden exploration, intended to prove the presence of these older rocks below the Wealden area, leaves the question still open as to the correctness of the views propounded by Mr. Austen with relation to the extension of the Boulonnais and other rocks. Speaking of the axis of Artois, Mr. Austen says,† "that it is continued across our area by the range of the North Downs, and those of Hants, and that on the north limit of this ridge the beds dip suddenly and rapidly; hence a line of fractures extending from near Arras to the east end of the Boulonnais and from the north-west point of the Wealden denudation to the Valley of Devizes." This relative depression on the north has preserved the Nummulitic series (Lower Tertiary), just as along the Franco-Belgian line the depression was the cause of the preservation of the great coal trough. Applying this consideration to the structure of our area, from Kent into Somerset, we may feel sure that a like arrangement of the older strata was from the Valley of the Thames into the Kennet; *along this line the coal measures may be reasonably supposed to have been preserved.*‡

* Vide POPULAR SCIENCE REVIEW, vol. xi. p. 237–240. 1872.

† "Quarterly Journ. Geolog. Soc." vol. xii. p. 62.

‡ Vide pl. VII., fig. 8.

Should the Somersetshire coalfield be repeated to the east, which is by no means improbable, we should then expect to find that extension under the great plain of Salisbury and the Kennet Valley, by Hungerford and Newbury, thus meeting the Belgian prolongation from the east 25 miles due north of Marlborough. The Burford trial has proved an extension of either the Forest of Dean or the Bristol coalfield, or both, at (as before stated) 1,184 feet in depth; and it is 35 miles east of the two coalfields named, and thus much nearer the areas predicted by Mr. Godwin-Austen.

Professor Prestwich, in evidence before the Royal Commission,* favoured the view of this easterly extension from the present boundary of the Bristol coalfield, and knew no reason why a coalfield may not be entirely covered up east of Bath, or Radstock, &c. Again we refer to the Burford boring as tending to confirm Professor Prestwich's views.

The axis of Artois, which plays so important a part in the physical structure of the region through which it passes is traceable from the Mendip Hills to the old county of Artois in France; and the singular unconformable relation of the Oolitic beds of Frome, &c., to the Carboniferous masses of the Mendip and its anticlinal, are the same as those of the Oolites of the Boulonnais. We now partly know what thickness the Jurassic rocks attain below the Wealden beds, in the Wealden area, where 1,990 feet have been passed through, 800 of which were Portland, Kimmeridge, and Oxford clay. So that the mooted point in Mr. Austen's paper (*loc. cit.*), to what extent the Oolitic group may exist below the Wealden and Cretaceous groups of Kent, Sussex, and Surrey, has been partly set at rest, but not decided either as to complete sequence, presence, or thickness, for nothing below the Oxford clay is yet known, and therefore the Palæozoic rocks or their age can only be inferred.

Sub-Wealden Area and its Exploration.

In April 1872, at the meeting of the British Association at Brighton, it was arranged that a trial should be made in the Wealden area, for the purpose of testing the presence of and depth to the Palæozoic rocks beneath the secondary strata of the Wealden. This undertaking had a twofold bearing; the first being, as before stated, to test the thickness of the overlying secondary rocks, and the age of those older series that may be beneath them. The second had special reference to the solution of the problem propounded by Mr. R. Godwin-Austen, relative to the existence and extension of the coal measures or

* Report of the Commissioners appointed to inquire into the several matters relating to coal in the United Kingdom. Minutes of Evidence, pp. 146–418.

other Palæozoic rocks ranging from the Belgian and north French areas towards or under the south-east of England. A spot at Archer's Wood, Netherfield, near Battle,* was selected to determine this, by means of the diamond boring process, and no less than 1,998 feet were passed through, ending in the Oxford Clay at that depth. The Purbeck and Portland beds were but thinly represented in the boring; but the Kimmeridge Clay, of unprecedented thickness, equalled nearly 900 feet, or three times its normal thickness; this doubtless was owing to the depression of the Wealden area during the deposition of the Kimmeridge Clay, its accumulation being equal, *pro ratâ*, to subsidence. From top to bottom of this formation it was richly fossiliferous, every core yielding the characteristic Kimmeridge fossils. The Coral Rag was passed through, and the bottom of the boring-rod, with its diamond crown, was forced to yield to circumstances and end in the Oxford Clay. The first and only attempt to solve an important problem, purely for scientific purposes, was thus abandoned owing to the smallness of the core, and we still remain in ignorance and doubt as to the nature and depth of the older rocks in the south-east of England. The name of Willett will ever be honourably associated with this memorable undertaking, for at his suggestion and through his laborious efforts and labours, and under his guidance, it was commenced and continued; the ending and stoppage being due to want of machine power to penetrate deeper, and the too rapid decrease in the diameter of the cores. Subsequent boring, however, in search of water in the heart of London, at 1,140 feet revealed the Upper Devonian rocks, thus clearly showing that the expected and sought-for Palæozoic rocks should be, and doubtless are, under the Wealden area, but whether Coal Measures, Carboniferous Limestone, Devonian or Silurian, we have yet to learn. In Calais the Coal Measures were touched at 1,032 feet; Kentish Town, red rocks below the Gault at 1,114 feet; Devonian, in Tottenham Court Road, at 1,140 feet; at Crossness, red sandstone at 1,056 feet; thus showing that a broadly spread floor of Palæozoic or most ancient rocks is spread under the extensive region of the south-east of England.

To show still more conclusively the extension and easterly spread of the older rocks from the westward, we cannot pass over the important boring at Bradwell, near Burford, in Oxfordshire, where at the depth of 1,184 feet the Coal Measures were determined, several species of characteristic coal plants being brought up in the cores. Whether we are to look for a southern prolongation of the Warwickshire or South Staffordshire coalfield, or whether it is the setting in of another extensive coal-

* Vide pl. vii. sections 1 and 3.

field east of the Forest of Dean or Bristol basin is a question; it adds greatly, however, to the extension of the Palæozoic rocks towards the London basin, and enriches our knowledge as to the palæogeography and physiography of the coal tracts probably hidden under the Jurassic and Cretaceous rocks of Oxfordshire, and possibly of Berkshire and Middlesex. All the lower Secondary rocks were passed through in the Burford boring, but evidently attenuated on the line of dip.*

Other borings, exactly on the same latitude, 80 miles to the eastward, and at less depth, reveal or shadow forth what is the nature of the physical geography and geology between the two points; hidden as it is, its subterranean features can be broadly sketched. The outlines of this palæogeographical problem have been almost prophetically dealt with both by Mr. Godwin-Austen and Professor Prestwich, and there can be little doubt that owing to the absence of all the lower Secondary formations, the Tertiary and Cretaceous rocks in the London basin repose directly upon a floor of older Palæozoic rocks; such has long been the view held by these two distinguished physicists. We have now only to define the area and nature of that floor, the age of the rocks composing it, and its relation to the old rocks of western England or of western Europe.

Ware, Hertfordshire, and the older Rocks.

Being desirous to increase their store of pure water, the New River Company (through the Diamond Boring Company) put down a trial boring near Ware, commencing their operations in Chalk, and immediately north of the outcrop of the London Clay, which so well defines the district. Less perhaps was known of this immediate area than any within a radius of 50 miles from London, so far as underground geology is concerned.

The central position of Ware, with respect to the supposed conformation and structure of the basin rendering it probable that the two Greensands below the Chalk, or one of them, would yield a very large supply of pure water, operations were carried on through the Chalk, Upper Greensand, and Gault, by the Diamond process, and cores brought up over 1 foot in diameter to the depth of 800 feet. The Chalk and overlying gravel measure 558 feet, the Upper Greensand 77 feet, and the Gault 160 feet, all perfectly horizontal, and the Lower Greensand was unmistakably represented by a thin stratum of the 'Car Stone' much washed away through the operation of boring. This rather

* Lower Oolite, 148 ft.; Lias, 598 ft.; Rhætic, 10 ft.; New Red Sandstone, 418; Coal measures, 325 ft., passed into.

coarse-grained loose bed of sandstone underlay the Gault, and rested immediately and most unexpectedly upon the old and highly-inclined Palæozoic rocks—a Silurian floor of the Wenlock age, dipping at an angle of 40°, but to what point of the compass at present we do not know, although probably to the south.

Not long since (June 1877) it was our good fortune to announce the discovery of the Upper Devonian rocks, under Tottenham Court Road, at Messrs. Meux & Co.'s Brewery, at the greater depth of 1,140 feet. They were penetrated 70 feet. This new feature in the palæogeography of the eastern counties, anticipated in some form by Austen, Prestwich, and Hull, is now verified, and the age of the rocks determined.

It will be asked by those who give attention to stratigraphical geology, whether these Silurian rocks are of the British or Continental type; in other words, are they or can they be correlated with our Welsh or English Wenlocks, or are they of the Ardennes type? Do they constitute a portion of the Dudley or Wenlock rocks of Wenlock spreading away eastwards, or are they a prolongation of the Silurian rocks of Belgium—the western edge or extension of which reaches beyond the longitude of Greenwich? In other words, were these two separate basins, or one? Is it an extension from the West of Europe, or an easterly expansion of the Upper Silurians of the Silurian area?

The facies of the fossils and the character of the rock in all its essentials are decidedly British, and it cannot be doubted that they are a continuous and denuded surface of the same rocks now conspicuously exposed in the picturesque scenery of the hills of Herefordshire and Worcestershire. The thirty species of fossils noticed in the cores are, species for species, identical with those of the Wenlock Edge, or Wren's Nest, near Dudley, and no difference can be detected in the lithological characters of the rocks.

In direct line or latitudinally the Wenlock rocks of the Malvern, Woolhope and May Hill may claim connection, but we regard the Ware fossils and rock as having more affinity with the Wenlock Edge series, or that group which borders and underlies the western side of the great mass of the Old Red Sandstone of the north-west part of Herefordshire, although distant nearly 160 miles. Could we remove the overlying Mesozoic series between Ware and Burford, in Oxfordshire, and again expose the Coal Measures known to occur there at the depth of 1,184 feet, then should we understand the thinning away of the Jurassic and lower Cretaceous series eastwards towards this Silurian ridge, and what we should probably call the Oxfordshire and Hertfordshire coal basins would be exposed and correlated, for we can hardly now doubt this extension of the known Burford Coal Measures, in all probability, however,

terminating westwards of Ware against the Silurian series, the physical geography aspect of which at the time of the coal growth must have been much the same as the present, could the 80 miles area be re-elevated from 800 to 1,000 feet.

Another boring is being carried down by the New River Company at Turnford or Wormley, six miles south of Ware, the revelations from which are more than anxiously looked for. This piece of engineering skill it is intended to complete as far as passing through the Lower Greensand. The Turnford boring is now 980 feet deep, and still in the Gault; it is therefore 200 feet lower than the bottom of the Ware rocks. This increased depth is owing to a depression, or perhaps valley, in the Palæozoic land below, which seems more than probable, when we know that the same thickness of Gault occurs over the northern area generally. It is 160 feet thick at Ware, Turnford, Loughton, Kentish Town, and Tottenham Court Road; at Crossness, 140 feet. In most cases, when bored through, this Gault has a floor composed of Palæozoic rocks; at Kentish Town a red micaceous sandstone; at Tottenham Court Road the Lower Greensand rests upon a true Upper Devonian; at Ware on the Wenlock rocks of the Upper Silurian, and at Crossness on red sandstone (age ?). We are thus justified in stating that the space between Messrs. Meux's, at Tottenham Court Road, and Ware—a distance of 24 miles—is occupied by the Upper Silurian, and probably the Lower, Middle, and Upper Devonian rocks, which may be rolled and folded on their dip. To what distance rocks of older date may occur north of Ware, further experiment only will decide. Harwich—which lies ten miles further north, and probably on the strike—has revealed them at a depth of over 1,000 feet.

Few, perhaps, are aware of the difference that exists in the thickness of rocks of the same age in different, yet not very remote localities. In Britain the Cambrian and Lower Silurian deposits are from 20,000 to 30,000 feet in thickness; whilst in Sweden and Russia the deposits which are the equivalents and representatives of these epochs rarely, if ever, exceed 1,000 feet. This difference is due to the form and nature of the pre-Cambrian land on which the newer series, Cambrian and Silurian, are placed; for there cannot be any doubt that such pre-Cambrian land did exist, and extended over the present known European area, with probably a great expansion westwards of the British Islands and the Spanish coast. The old plateau beforenamed is part of this extension. I believe also that the crystalline rocks of Scandinavia to the north constituted a part of this pre-Cambrian stage, and also parts of North Wales, and the north-west of Ireland. The Hebrides and St. David's are remnants of this epoch of the highest antiquity. This old land must have been slowly submerged and denuded to receive the so-called

Cambrian and Lower Silurian rocks, those which are now known by the name of the Longmynd and Harlech, with the succeeding Lingula Flags, Tremadoc and Arenig, life groups of antiquity so high that we have no formula to express their age.

We have no evidence yet as to these rocks of highest antiquity occurring eastwards of the Pennine axis, of which Charnwood is a prolongation; and longitude 1°50′ W. limits the easterly surface exposure of the lowest Palæozoic rocks, and these are the Charnwood slates, &c., of yet undetermined age. The problem still remains unsolved; but the Ware trial has revealed a group of rocks at a depth of 800 feet that shadows forth older rocks still, and should the dip of these Hertfordshire Silurians prove to lie to the south, we may anticipate the more ancient series further north towards Cambridge. Be it remembered that the strike from Ware in that case would be directly towards Harwich. The four trials are from London due north. At two of these (Ware and Turnford) the true direction of the dip will, it is hoped, be tested and determined, the solution of which is worthy of all experiment and patience. If successful, it will be the key by which the hidden structure and wealth of any given area in Britain may be tested.

What are the Old Rocks South of the Thames?

Since the determination of the presence of the Devonian rocks at Tottenham Court Road, north of the Thames, and the Upper Silurian at Ware, 24 miles further north, our views relative to the distribution of the Coal Measures have materially altered. It would now appear from recent research, that there is little chance of any rocks younger than the Devonian occurring due north of London, beyond latitude 52° 30′ N., or east of longitude 1° W. Whatever may be the contour or disposition of the old Devonian and Silurian land at from 800 to 1,000 feet deep it is clear that all the stratified rocks between the Devonian and the Gault are wanting; in other words, the whole of the Carboniferous series, the Permian and Triassic, the Jurassic including the Lias, and the Purbeck and Wealden are wanting or missing north of the Thames to the latitude above-named. This shows the great unconformable overlap upon the Silurian and Devonian floor, which became submerged to receive the upper Secondary rocks whose outcrop now extends throughout the length of England, from Redcar in the north-east to Teignmouth in the south-west, and which also fill the great depression which extends from the Mersey and the Dee to Burford in Oxfordshire, where it is 756 feet deep, as proved by the boring. How much further east it may extend we know not, but little west of London it seems to

have thinned away, as do most of the Secondary rocks, probably against the Palæozoic plateau.

The key to the underground Palæozoic geology of the country south of the Thames, *had it been completed*, must have been the sub-Wealden boring. Unfortunately for science, the problem was never solved, the nearly 2,000 feet of Secondary strata passed through being all above the desired or anticipated ancient land. The fact that the Upper Devonian rocks were under the heart of London, and the Silurian some miles north of that, induces us to believe that we must look to the south of London, as pointed out by Mr. Godwin-Austen, as the area where we should expect to find the Coal Measures, ranging probably under or north of the North Downs. Their southern extension, until revealed through necessity or enterprise, will remain unknown, but we doubt not their presence.

Palæontology of the Upper Silurian and Devonian Rocks north of London.

The extensive area north of London occupied by the Tertiary strata as far as Ware, with the Chalk beneath, is now known to be underlain by other rocks of high antiquity, now determined to be, through organic remains, the Upper Silurian, and closely resembling, if not identical with, the Wenlock group of the Wren's Nest, near Dudley, or even the more distant groups of the Wenlock Edge or the Ludlow Promontory. The facies of the fossil contents of the Upper Silurian cores at Ware is not that of the Malvern or Woolhope series, or of the still nearer beds at Tortworth, although nearly in the same latitude; nor can they be correlated with the Upper Silurian series of the Ardennes in Belgium, from which they essentially differ. There can be no doubt of their affinity with the true Silurian rocks to the west of the Severn Valley, or the Dudley group, thus incontestably proving the easterly continuity and extension of the latter. So rich in fossils are these Ware Silurians, that no less than thirty-three species have been obtained; every portion teems with extinct life, especially Brachiopoda, twenty-one of the thirty-three species belonging to this group. The characteristic trilobite *Phacops caudatus* with *Ischadites Kœnigii*, Crinoidea, and Orthoceratites, are sufficient data in themselves to establish both the age and affinity of the fossils, which now are known to occur on this floor 800 feet deep, on which rest the Cretaceous and Tertiary series of Hertfordshire. The following list will show the rich fauna of the Wenlock Rocks below Ware. All the fossils were obtained from a core less than three feet in length and one foot in diameter.

I. Protozoa . . .	1. *Ischadites Kœnigii*, Murch.
II. Echinodermata . .	2. *Taxocrinus*, sp. 3. *Periechocrinus moniliformis*, Mill
III. Annelida . . .	4. *Tentaculites ornatus*, Sby.
IV. Crustacea . . .	5. *Phacops caudatus* Brünn.
V. Mollusca-Brachiopoda .	6. *Orthis canaliculata*, Dalm. 7. ——— *elegantula*, Dalm. 8. *Meristella tumida*, Dalm. 9. *Cyrtia exporrecta*, Wahl. 10. *Spirifera elevata*, Dalm. 11. ——— *plicatella*, Linn. 12. *Athyris*, sp. 13. *Crania implicata*, Sby. 14. *Rhynchonella cuneata*, Dalm. ? or *deflexa*, Sby. 15. *Atrypa reticularis*, Linn. 16. *Pentamerus galeatus*, Dalm. 17. ——— *linguifer*, Sow. 18. *Strophomena euglypha*, Dalm. 19. ——— *reticulata*, McCoy. 20. ——— *depressa*, Dalm. 21. ——— *rhomboidalis*, Wahl. 22. ——— *antiquata*, Sby. 23. *Chonetes*, sp. 24. *Leptæna sericea*, Sby. 25. ——— *transversalis*, Dalm.
„ Conchifera . . .	26. *Pterinea*, sp. 27. *Mytilus mytilimeris*, Conr. 28. *Ctenodonta*, sp. 29. *Orthonota rigida*, Sby.
„ Gasteropoda . . .	30. *Euomphalus rugosus*, Sby.
„ Cephalopoda . . .	31. *Orthoceras attenuatum*, Sby. 32. ——— sp. 33. ——— *angulatum*, Wahl.

It may be asked what has become of some 20,000 feet of strata ranging from the Neocomian down to the top of the Upper Devonians, all the Coal Measures, Triassic, Jurassic, and Wealden series, being absent between Ware and London. No greater unconformity is known in the British Islands, or was suspected here until the boring for water by the New River Company revealed these grey argillaceous Silurian shales and fossils, dipping probably to the south, at an angle of 40°. The Jurassic Rocks must have thinned away west of Ware, Turnford, and London, against yet resting upon this unseen and hitherto unknown Silurian range. Whether all the should-be superincumbent strata named were ever present, and subsequently denuded, during elevation, we know not; but the presence of the Upper Devonian strata at Turnford, with their characteristic fauna, and at a lower geographical level, tends to show considerable movement.

At Turnford and at Tottenham Court Road the red fissile shales contain the same fossils—*Spirifera disjuncta*, *Pterinea*, and *Rhynchonella*, &c., being common to both places, thus

showing that the Devonian rocks occupy this area 1,000 feet below the surface through a known extension northward from London, of twenty-four miles.

The exposed Devonian Rocks of North Devon, on the one hand, and the Silurian Rocks of Wales on the other, are now proved, through their fossil contents, to be continuous to and to extend under the London Basin, striking below the German Ocean on to Belgium and Germany, holding, so to speak, on their denuded surfaces much of, if not all, the superincumbent strata of the south and south-eastern part of England; had the sub-Wealden boring touched the Palæozoic rocks at Battle, nothing more would have been desired to show the palæogeographical structure of the south-east corner of Britain and our relation to north France and Belgium.

REVIEWS.

ELECTRICITY.*

NO branch of experimental science has passed more decidedly from its first or inductive stage into its second or computative, during the last thirteen years, than that of Electricity. Many who studied it lovingly and with appreciation at the former period will admit with willingness their obligations to the original Text-book of Dr. Noad, as well as to the bulkier Manual by the same author which preceded it. It was at the time singularly complete and exhaustive. In the preface, dated from the School of St. George's Hospital, in September 1868, its precise position in the chronology of physics is accurately dated, by the cordial acknowledgment accorded to that "beautiful electrical instrument invented by Professor William Thomson, F.R.S., namely, his Portable Electrometer," and by the prefatory note on the recovery of the first, and the successful laying of the second, Atlantic Cable. The preface reappears in Mr. Preece's revised edition in contrast with the editor's Introduction. In this he evidently, to a certain extent, grasps the progress since then. "All sciences," he says, "in their earlier stages excite the imaginary powers of the mind" (a phrase which is probably intended to mean the imagination), "but in their later stages the calculating powers. The study of Electricity has been a fine sphere for hypothesis; but it has now become a cultivated field for the exercise of the quantitative tendency of the mind;"—an obscure sentence which probably shadows forth the idea that from hypothetical, Electricity has, by increased mental cultivation, become computational. In the same rather hazy, jaunty, and unsatisfactory prologue, which occupies very little more than four pages, we are told that recent discoveries "have rendered it an exact science," and that, notwithstanding this fact, "theory has been as much as possible excluded; first, because there really exists no theory of Electricity properly so called; and secondly, because what theory there is is used more for illustration than for explanation;" statements which appear to be somewhat self-contradictory.

A feeling of disappointment thus instinctively produced at the outset does

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* "The Student's Text-book of Electricity." By Henry M. Noad, F.R.S., &c. A new edition, carefully revised, with an Introduction and additional chapters, by W. H. Preece, M.I.C.E., &c. Crown 8vo. pp. 615. London: Crosby Lockwood & Co., 1879.

not diminish on going more deeply into the revised edition. All the early chapters seem to be very little altered from what was presumably up to date in 1866, but which is slightly antiquated now. To the end of the fourteenth chapter on Diamagnetism, there has been so little change that page 291 of the new edition corresponds with page 283 of the original work. The whole of this chapter, with the exception of the pagination, is evidently printed from the old plates, no notice being taken of the rotation of the plane of polarization from the polished pole of an electro-magnet, nor of that recently established to be experimentally determinable in air and gases. The fifteenth, sixteenth, seventeenth, and eighteenth chapters appear to have received addition amounting to only 68 pages in 485. Short chapters have been introduced on Duplex and Quadruplex Telegraphy, the Telephone and Microphone, and the Electric Light, which raise the size of the new volume 92 pages in all over its elder brother of 1866. The result is patchy and unsatisfactory; partly because the new and the old cohere badly; but more because the totally changed point of view in which the whole subject is now regarded, and which is acknowledged in the preface, fails to be realized in the body of the work. It would be ungracious to point out specific errors, of which there are many. One instance, however, which occurred to the writer may be noted. He turned immediately to the article "Condenser," for fresh information on the great development which this apparatus has of late years received, hoping to obtain practical hints for the use of mica, paraffin, and other dielectrics. There is not a syllable on the subject, beyond what was in the original edition.—W. H. STONE.

ORGANIC CHEMISTRY.*

THE reader will be disappointed if he expects to find in this little volume a good general outline of Organic Chemistry. The contents remind one of a student's note-book in the way statements are crowded together, unaccompanied by sufficient explanations, and not unfrequently damaged by inaccuracies. For instance, ethyl diamine stands for ethylene diamine (p. 16); trimetho-dichloride for trimethyl-arsine dichloride (p. 25); ethylene dichloride for dichloride.

We are told that "methyl alcohol is an inflammable colourless liquid, having an odour somewhat like ordinary alcohol, and a burning taste." "It is generally used as a substitute for ordinary alcohol on account of its cheapness, and these two are mixed and sold as methylated spirit" (p. 47).

Pyrogallic acid is said to have the composition C_5H_5O (CO.HO) instead of $C_6H_3\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right.$—an important difference (p. 127).

About 170 pages are devoted to this part of the book; the remaining portion being answers to questions from the Examination Papers of the Science and Art Department.

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* "A Manual of Organic Chemistry." By Hugh Clements. Sm. 8vo. London: Blackie & Son, 1879.

THE GAULT.*

MR. PRICE has conferred a boon on the student of Cretaceous geology by the publication of his work on the Gault, the result of some years' special study of that formation. It comprises a succinct account of the geographical distribution, lithological characters and fossil contents of this, the chief argillaceous member of the Cretaceous system; from which we learn that the sea, in which this deposit was formed, must have occupied an extensive area in what is now part of south-east England and part of the Continent, so that its waters on the west washed the Triassic and Jurassic cliffs of the midland counties, and to the east its waves beat against the northern sides of the Hercynian mountains.

From the varying mineral character of these old coast lines, the nature of the deposit, although mostly argillaceous, must have slightly differed according to locality, as described by the author, while the now imbedded fauna would differ somewhat in character according to depth, and hence probably the number of zones described by Mr. Price, as well shown in the sections at Folkestone and elsewhere.

Chapters are devoted to the geographical range of the formation, and a valuable table of 800 species of fossils arranged under twenty localities, occupies about half the work, which also contains a full bibliography and comparative tables of strata, so that the entire work forms a useful handbook, as intended by the author, of the Gault formation.

CAMBRIDGESHIRE GEOLOGY.†

THE Sedgwick Prize was established for the purpose of rewarding the writer of the best essay on some subject of Geology, and is given every third year. The competition is, however, restricted to graduates of Cambridge under certain restrictions. The last essay for 1873 treated of the Potton and Wicken phosphatic deposits, and the subject proposed for 1876 was "The Post-Tertiary Deposits of Cambridgeshire." The Prize was awarded to Mr. Jukes-Browne; but circumstances prevented the publication of his memoir until the autumn of last year, and our notice has been unfortunately delayed. The various drift and superficial deposits of the county have engaged the attention of geological writers since the beginning of this century; but the object of the present essay is to add more facts to the stock of information on these points, and to present as complete an account as possible of the accumulations met with in the Cambridgeshire district.

After giving a general account of the literature of the subject, the author treats of the physical features of the county, of the glacial deposits, followed by a description of the hill gravels, the valley gravels of the early and present

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* "The Gault:" being the substance of a Lecture delivered in the Woodwardian Museum, Cambridge, 1878, &c. By F. G. H. Price, F.G.S. 8vo. London: Taylor and Francis, 1879.

† "The Post-Tertiary Deposits of Cambridgeshire:" being the Sedgwick Prize Essay for 1876. By A. J. Jukes-Browne, B.A., F.G.S. 8vo. Cambridge: Deighton, Bell & Co.; London: G. Bell & Sons, 1878.

river systems, and the correlation of the Cambridgeshire drifts with those of the eastern counties.

In conclusion Mr. Jukes-Browne offers a few remarks on the conditions under which the glacial deposits have been formed, and the age of the principal features of the country—questions which have been much contested, and certain opinions connected with which he briefly criticizes, and explains his own views upon them.

Without, however, attempting to give a history of the manner in which Cambridgeshire was moulded, the author gives his views as to the relative age of its principal physical features from the evidence he has brought forward, and states that "the whole succession of post-glacial valley gravels seems indeed to have been singularly well preserved in this part of England, and if the various beds could be thoroughly disentangled, they would mark out the courses of the streams at different times, and present us with a picture of the successive changes which have taken place in the river system from the glacial period to the present time."

To the student of Post-Tertiary Geology this will be an acceptable essay, as the descriptions are given in a clear and systematic manner, embodying not only the author's own researches, but those of other geologists who have specially studied these deposits.

THE ELECTRIC LIGHT.*

THIS is an enlarged issue of the pamphlet by Mr. Shoolbred, already noticed in the two articles upon the Electric Light in our numbers for January and April. It contains a fair description of the various dynamo-electric machines lately invented; and, although Mr. Chapman's gravity lamp, which by many years preceded similar recent contrivances, and quite equalled them in performance at the recent exhibition in the Albert Hall, is still excluded, those now before the public are illustrated and explained. The plates are on a good scale, and easy to understand. Mr. Shoolbred is evidently a thorough and uncompromising advocate of this mode of illumination; so that any adverse facts or opinions must be sought for elsewhere.

THE HEAVENS.†

"Spake full well, in language quaint and olden,
One who dwelleth by the castled Rhine;
When he called the flowers so blue and golden,
Stars, that in Earth's firmament do shine."

MR. PROCTOR might well have added the above verses of Longfellow to the stanza of Shelley which adorns his prefatory page. They would complete the simile which evidently underlies his quaint and fanciful title.

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* "Electric Lighting and its Practical Application, with Results from Existing Examples." By J. N. Shoolbred, B.A., &c. 8vo. London: Hardwicke & Bogue, 1879.

† "The Flowers of the Sky." By R. A. Proctor, &c., &c. With fifty-four Illustrations. 8vo. London: Strahan & Co., 1879

Indeed, through nearly all the superscriptions of his works, there runs this pleasant archaic flavour, reminding the reader of an old library, of George Herbert, and Sir Thomas Browne. Nor is the tone of their contents dissimilar to the promise of the title-page. Although dealing with subjects exceptionally "dry," Mr. Proctor is what, for want of a better antithesis, we cannot refrain from calling, the most succulent of expositors. To men of formal, rigid, and "tetragonal" minds, this is perhaps a fault, a detraction from the sternness and severity of science. Contradicting the stoic exclusiveness of οὐδεὶς ἀγεομέτρητος εἴσατο, he says, Come hither, ye unlearned, while I discourse in simple and untechnical language of light, and space, of the infinitely minute, of the mystery of gravity, of the end of many worlds. Such, indeed, are the headings of his first five chapters. Nor are those which follow on the Aurora, lunar halos, moonlight, the planets, Mars, Jupiter, and the "winged Saturn," or on "fancied figures among the stars," treated with less of his usual fluency and discursiveness. The last chapter is on "transits of Venus." Here we must confess to a slight reminiscence of Mr. Dick, in the true history of David Copperfield, "who had been for ten years endeavouring to keep Charles the First out of the Memorial." But on this occasion we are only very gently reminded of the great controversy between Halley's and Delisle's methods of observing those important phenomena. As before, so now, we hold the opinion that these books are useful, and appeal to a class of readers who stand in awe of sines, cosines, and co-efficients.

W. H. Stone.

FIELD GEOLOGY.*

THE substance of this book, originally given as two lectures upon geological maps and instruments of surveying, in connection with the Scientific Loan Collection, has been considerably enlarged and revised, so as to form a new and independent work.

The long experience of Professor Geikie as a field geologist and Director of the Survey will fully qualify him to supply the wants of a large body of readers, who, having a general and even extensive knowledge of geology, find themselves to a great extent helpless when they try to interpret the facts they meet with in the field. Field geology is broadly distinguished from the researches which may be carried on in the library or the laboratory, and hence the object of the author has been to describe the methods by which the geologist may obtain his information regarding the nature, position, arrangement, and structure of a country. The subjects are arranged under two divisions—outdoor and indoor work, the former occupying by far the larger portion.

In the series of chapters composing the first part, which is well illustrated, the author describes the nature of field work, the necessary accoutrements, geological and other maps, the essential characters and origin of rocks, the nature and use of fossils, the unravelling of geological structure as connected

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* "Outlines of Field Geology." By A. Geikie, LL.D., F.R.S. Second Edition. Sm. 8vo. London: Macmillan & Co., 1879.

with dip, strike, and faulting of rocks, and their curvatures, contortions, and cleavage, the nature of igneous and metamorphic rocks and mineral veins, with a chapter on surface geology as connected with physical features.

The second part treats of the nature of indoor work, as drawing geological sections, hints for the determination of minerals and rocks, and the method of preparing sections for investigation by the microscope. The drawing of geological sections is of much importance, considering how frequently false ideas are given by diagrammatic representations of the external form of the ground, thus tending to perpetuate erroneous notions with regard to the physiography of the land as shown by such distorted sections, sometimes almost grotesque in their exaggeration of natural forms. Similar erroneous notions apply to some drawings of unconformable stratification. We can corroborate Professor Geikie in his remarks on this structure, having recently seen drawings of much more impossible unconformities than even that given by him at page 113.

We may notice among the few typographical errors the letters *a c* of the woodcut, fig. 29, which are wrongly described, indicating an inversion of the strata, which is not the case, as shown by reference to the original figure (174), from which it is taken in the "Geological Observer." At p. 109 is described a ready means of estimating the thickness of strata, which appears more simple than that proposed by Professor Chapman. In this paragraph the author might have usefully alluded to the method of calculating the depth from the surface at which an inclined stratum might be reached at a given distance from the nearest outcrop.

To the geological student who is acquainted merely with the principles of the science derived only from book-study, this concisely arranged and pleasantly-written text-book by Professor Geikie, for guidance in the field, will be a valuable aid, as pointing out how and what to observe and how to record, thus adding fresh interest to his studies, and ministering to his further elevation and enjoyment, by a more practical knowledge of the nature of the district in which he finds himself situated, or into which the pursuit may lead him.

FRAGMENTS OF SCIENCE.*

WE need do little more than announce the publication of a new and enlarged edition of Professor Tyndall's "Fragments of Science." Deservedly recognized as one of our most brilliant writers on subjects connected with physical science, Professor Tyndall has the art of investing with a peculiar charm matters which at first sight might seem rather unpromising, while at the same time he is a most lucid popular expositor of scientific facts and theories. These circumstances make it no matter of wonder that the collection of essays, reviews, lectures, and addresses which he brought out a few years ago under the above title should have already arrived at a sixth edition. Of course, there are portions of these articles at

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* "Fragments of Science." A Series of Detached Essays, Addresses, and Reviews. By John Tyndall, F.R.S. Sixth edition. 2 vols. Crown 8vo. London: Longmans & Co., 1879.

which even scientific men may cavil; and there are others, and indeed whole essays, which are regarded by certain unscientific readers as utter abominations, such as the discourses upon prayer and miracles, and the celebrated Belfast address; but the dispassionate reader, if any such can be found, will discover that there is a good deal of truth in them, and that the views they open up are at all events worth consideration. The present edition contains several new articles, among which the most important seem to be those on Fermentation and Spontaneous Generation, and the reply to Professor Virchow's commination of the Evolutionists. The author's lecture on the Electric Light is also included. As these and other additions have caused a considerable increase of bulk, the book is now divided into two volumes.

THE SEA-SHORE.*

TO the naturalist the sea-shore is so prolific of objects of interest, and the sea-side visitor is so often in want of something to interest him, that the constant crop of popular books describing, in more or less detail, the natural history of the sea need not excite much surprise. People can't be always walking up and down the pier or the parade, or listening to indifferent brass bands; and if the majority of those who try the natural history line don't make much of it, their efforts, at any rate, can do them no harm. Hence we are inclined to welcome every fresh addition to the popular literature of the shore, and we do this with particular satisfaction when the newcomer is the production of a good naturalist, and worthy of its parentage.

The latest accession to littoral literature, if we may use such an expression, forms one of a series of small volumes published by the Society for Promoting Christian Knowledge, under the general title of "Natural History Rambles," and is by Professor P. Martin Duncan, whose work, whether technically scientific or of a more popular character, is always good and sound. Taking as his title "The Sea-Shore," Dr. Duncan does not confine his attention to the marine plants and animals which may be picked up on the beach or found in rock-pools, but treats his subject from a broader point of view, so as to show in a general way all the directions in which sea-side rambles may be made interesting and instructive. Thus, by way of defining what is the sea-shore, he indicates the geological phenomena of shore-formation, and passes from these to general considerations on the zones of life fringing our shores, and in a second chapter describes the characteristic terrestrial plants of the shore. In the latter part of this chapter, however, he gives an account of the true littoral sea-weeds; and from this to the last chapter, which treats of the birds, we are throughout confined to the briny element.

The subjects are arranged in systematic order, and the ten chapters relating to animal life furnish an excellent summary of marine zoology, in which the appearance, habits, structure, and physiology of the animals treated of are

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* "The Sea-Shore." By Professor P. Martin Duncan, M.B. (Lond.), F.R.S. Sm. 8vo. London: Society for Promoting Christian Knowledge, 1879.

described with great clearness and with an almost total absence of so-called hard words. Indeed, the principal thing that a naturalist would be inclined to find fault with in this book is the, perhaps excessive, avoidance of technicalities, the desire for which has evidently often hampered the author and led him to make use of a phraseology, to say the least of it, a little uncouth. The little book is pretty freely illustrated with fairly good wood-engravings.

BRITISH BIRDS.*

TO the fortunate resident in country places who takes an interest in natural phenomena there are in general no more attractive objects than birds. The most prominent of the living elements of the landscape in most places, interesting from their elegance of form or beauty of plumage, and still more from their habits, the most unobservant of countrymen is perforce to some extent a student of birds, even though his more intimate acquaintance with them may be limited to his boyish experience of plundering their nests, or, somewhat later in life, to a vigorous persecution of them with his first gun. Hence, practically, we find that of all departments of natural history, ornithology is that of which a knowledge (scanty, it is true, in the majority of cases) is most generally diffused, and there is no other group of wild animals about which the desire for knowledge is greater than the class of birds.

Under these circumstances it is no matter for wonder that the literature of British ornithology is tolerably extensive; and, in fact, we have books enough—good, bad, and indifferent—which give a more or less satisfactory account of the characters and habits of the avian inhabitants of these islands. Captain Moore has, however, struck out a new line in this respect, and has produced a most unpretending book, which, we think, will prove of no small use as a work of reference both to the general observer and to the serious student of British birds. In a series of five tables he has systematically arranged the whole list of recorded British birds, and furnished in parallel columns nearly all the information that can be given as to their geographical distribution and migrations. Even the actual list is instructive. The birds are divided into three main categories—residents, migrants, and rare (or occasional) visitants; and the second set are further divided into summer and winter visitants, so that the names of the birds stand in four columns, and the proportion of residents to migrants comes out in a most striking and rather surprising fashion. Thus, one is hardly prepared to see that out of 376 recorded British species only 114 are permanent residents in these islands, whilst 136 are true migrants, or regular summer or winter visitors, and no fewer than 126 fall under the designation of occasional visitants. Of the wading and swimming birds especially, the proportion of wanderers is very large, the number of species of these two orders, which are either migrants or occasional visitors, being about four times as great as that of the permanent residents.

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* "British Birds: systematically arranged in five tables, showing the comparative distribution and periodical migrations, and giving an outline of the geographical range of 376 species." By G. Peter Moore, F.L.S. 4to. London: Van Voorst, 1879.

Now it is with regard to these wandering birds that Captain Moore's tables are particularly interesting, for he indicates their distribution in other countries, and, in the case of migrants, the time of the year in which they are met with elsewhere, thus bringing into a very convenient form for reference a great body of information upon all matters connected with the geographical distribution and migrations of our British birds. Thus, if we take a common and well-known species, such as the martin, we get the following information about it in a single line—it occurs in summer throughout the British islands and all over the Continent of Europe, is a bird of passage in the islands of the Mediterranean, occurs in summer in Iceland and the Faroe Islands, is a rare resident and winter visitant in Palestine, occurs in southern Siberia in summer, in the north-west of India and in Arabia, and in Egypt, Nubia, and Abyssinia in the winter. In northern Africa it is also of course a bird of passage. In like manner with other species the whole distributional history of each is indicated by a few symbols and letters placed in the respective columns under the heads of the different countries inhabited or visited by the birds. The book is in fact a tabulated summary of those points in the Natural History of British Birds which, although of great importance to the ornithologist, will most easily slip his memory, and the author's labour in preparing it, which must have been very considerable, ought to earn for him the gratitude of his fellow-students.

THE HUMAN SPECIES.*

A NATURAL History of Man, written by M. de Quatrefages, forms the twenty-sixth volume of the International Scientific Series, and we need hardly say that, like everything that comes from the pen of its distinguished author, this little work is excellent. M. de Quatrefages, as is well-known, is a strong monogenist in anthropology, and he devotes considerable space here to the development of his views upon the question of the unity or diversity of the species of man, which he settles, of course, in favour of the former. The main argument, naturally, is the unlimited fertility of the human races *inter se*, and the continued fertility of the crossed races, which certainly goes far enough to prove that the differentiation between the races has not advanced to the production of "physiological species." In connection with the question of the origin of mankind, the author also submits the doctrine of evolution to examination, and comes to a decision adverse to the acceptance of any such idea to account for the origin of species, upon grounds which do not appear to us to be of very great weight. The main objections raised by M. de Quatrefages to the doctrine of evolution, or, more properly, to the more advanced developments of Darwinism, are, that its upholders generally give no clear definition of what they understand by a "species;" and, secondly, that they cannot or will not say "they do not know," and therefore are inclined to assume that certain things have happened in accordance with the requirements of their theory, when it is quite possible that

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* "The Human Species." By A. de Quatrefages. 8vo. London: C. Kegan Paul & Co., 1879.

just the reverse has taken place. There is, perhaps, some ground for the latter reproach; but at the same time its justice can hardly invalidate the doctrine of evolution, as applied to plants and animals, which rests upon the observation of the phenomena of distribution of organisms in space and time, and by no means upon the success of the attempts that have been made by Darwin, Wallace, and others, to explain how the observed phenomena may have been brought about by secondary causes. The geographical distribution and geological succession of the species of plants and animals present certain general peculiarities which require to be accounted for; the theory that new forms (species) have always come into existence by the modification of the offspring of pre-existing organisms, seems to furnish the only *scientific* method of accounting for the observed facts; and the failure of Mr. Darwin, or of Professor Häckel, to explain all the steps by which the process has been accomplished cannot legitimately shake the theory.

These general biological questions occupy the first two sections of M. de Quatrefages's book, and after dismissing them he proceeds directly to the consideration of his main subject. The third section treats of the antiquity of man, and gives the evidence proving the existence of human beings at remote periods of the existing epoch; and, secondly, those more scanty indications of their having lived in Tertiary times. M. de Quatrefages is inclined to accept the evidence which carries back man in some localities to the Miocene, and seems to think that there is no reason why he should not have had a still higher antiquity. In succeeding books the author proceeds to discuss the original localization of the man, the course of his migrations in peopling the earth, and the phenomena attending his acclimatization in the various parts of it, all, of course, strictly in accordance with monogenistic views. Next, he considers what was the nature of the primitive man, as to which, it must be confessed, he not unnaturally leaves us considerably in the dark; but he maintains that the original formation of distinct races took place under the sole influence of the conditions of life and heredity, to be afterwards modified to a certain extent by intercrossing.

These general and more or less theoretical matters occupy about half the book; in its second half M. de Quatrefages treats first of the earliest races of which we have any reliable remains; and, secondly, of the characters, physical and psychological, of existing races. With regard to the latter he enters into no detailed examination of the different races of man; but discusses those characters and peculiarities, whether of mind or body, which serve for the distinction of races, and, of course, indicates in a general way the particular races in which these peculiarities occur. It is a treatise on the principles of ethnology, and not a formal classification of the races of man.

In taking leave of this very good book, we cannot but express our regret that the publishers do not exercise greater care in the selection of a translator for such works. In the present volume we find passages which are evidently not correctly translated; and the qualifications of the translator for dealing with such a book may be inferred from the fact that in one place he has given "Indian pig" as the equivalent of the French "Cochon d'Inde;" in another "mean Miocene" as the translation of *Miocène moyenne*, and in another ascribes the preservation of the history of the Norse inter-

course with America to Irish instead of Icelandic sagas, and actually calls Erick Upsi, bishop of Greenland in 1121, an Irishman! Surely it would be worth while for the publishers to go to a little extra expense to avoid such blunders as these, and escape from the inevitable suspicion that, where such occur, others, perhaps of more consequence and less easily detected, are to be expected.

TREES AND FERNS.*

MR. HEATH has published a small volume in which he treats of both his favourite subjects—trees and ferns—we presume with the object of reaching a public who would be deterred from purchasing his larger and more expensive books. It is, in fact, merely a reprint of the more general portions of his "Woodland Trees" and "Fern World," with a couple of chapters from the "Fern Paradise." As we have already noticed those works, we need say little about the present one, except that as giving certain details of the structure and mode of growth of ferns and trees in a popular form it may be recommended as tending to foster in the young a taste for botanical studies, and as furnishing a useful guide to the first steps of the beginner. With regard to ferns, some instructions in collecting and growing them are also given. Like Mr. Heath's former publications the little book is prettily illustrated.

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* "Trees and Ferns." By Francis George Heath. Sm. 8vo. London: Sampson Low, Marston & Co., 1879.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

An Elephant-pipe in North America.—Mr. J. D. Putnam has sent to the editors of the "American Naturalist" (see number for April, 1879) photographs of two pipes from a mound in Muscadine County, Iowa, one of them representing a bear, the other an elephant. The latter is so like an elephant in the head, body, limbs, and trunk, that although it shows no tusks, there is said to be no doubt that the maker of it had seen an elephant, and tried to reproduce its likeness in this pipe. Coupled with the discovery of an "elephant mound" in Grant County, Wisconsin, the occurrence of this relic seems to point to the co-existence of man and the mammoth in North America.

Simian Characters in Negro Brains.—Dr. A. J. Parker brought this subject before the Academy of Natural Sciences of Philadelphia (October 8, 1878). In one negro brain out of thirteen that he had examined, he has ascertained the existence of an internal inferior *pli de passage*, which was as well developed as in any of the Simiadæ. In that brain the convolution in question measured a quarter of an inch in width, and completely separated the parieto-occipital or internal perpendicular from the calcarine fissure, so that this region presented the same appearance that it does in the Simiadæ. The same convolution is uniformly present in all those animals, except in *Ateles paniscus*, according to Huxley, and in *Hylobates*, according to Bischoff. It has never before been found fully developed in man, and the absence of this small, bridging convolution has been regarded by some anatomists as a distinguishing characteristic of the human brain, as compared with that of the Anthropoid apes. In another brain of an adult female negro, one of twenty examined since the first discovery of this convolution, it was again met with, fully developed up to the surface, an eighth of an inch wide, and completely separating the two fissures above mentioned. This supposed simian convolution was therefore present in two brains out of thirty-three. Dr. Parker has also observed in the brain of an adult male negro the complete connection of the fissure of Rolando and the fissure of Sylvius.

ASTRONOMY.

Oxygen in the Sun.—Unquestionably the most important astronomical event during the last quarter has been the announcement by Professor

Henry Draper of the series of observations by which he has tested and confirmed the evidence he had obtained in 1877 respecting the presence of oxygen in the sun. It will be remembered that the negatives he had obtained in 1877 were on a scale equal to about one-eighth that of Angström's normal spectrum, the enlargements being four times as great. He has now obtained negatives as large as the former enlargements, or on half the scale of Angström's chart, so that the enlargements (fourfold as before) are on twice the scale of these reference charts. This is of itself a most important advance, indeed it may be doubted whether Professor Draper or anyone else will ever be able to pass much beyond this, seeing that the light of the electric spark in air which gives the comparison spectrum of oxygen, is scarcely equal to one standard candle. By comparison he finds that when the electric spark from his Gramme volatilizes iron, the light is sixty times stronger than the most vivid incandescence of air that he has been able to produce. Still further to improve the air spectrum, and thus to test the reality of the coincidences between the bright oxygen lines in that spectrum and bright parts of the spectrum of the sun, Professor Draper has devised what he calls the spark compresser. The condensed spark taken in the open air, or in a gas under atmospheric pressure, pursues, if unconfined, a zigzag course, and this is apt to produce a widening of the lines in the photographed spectrum. After many experiments, Professor Draper found that the spark might be compressed between plates of thick glass, or better still between two plates of soapstone. When the interval between the plates is directed towards the slit of the spectroscope the lateral flickering of the spark is prevented, while yet the spark is fully exposed to the slit without the intervention of glass or any substance on which the volatilized metal from the terminals could deposit. Very early in the research it became apparent that Plücker's tubes could not be employed with electrical currents of more than a certain intensity, partly on account of the deposit that took place in the capillary portion, and partly because the terminals became so hot as to melt and crack the glass. Moreover, it was desirable to use one terminal of iron so as to be sure that the spectrum of the gas was correctly adjusted to the solar spectrum, and this is impracticable with Plücker's tubes. An additional advantage arises from the soapstone plates, viz., the temperature of the small volume of air between the terminals is materially increased, and increased brightness results. The comparison photographs thus enlarged and purified show as perfect agreement between the oxygen bright bands and the bright parts of the solar spectrum as did those obtained in 1877. The value of the evidence given by each coincidence is increased fourfold; and it need hardly be said that that of the evidence from the complete series of coincidences is increased in much greater degree. In fact, as there are eighteen well-marked coincidences, it might theoretically be argued that the total value of the evidence is increased as $(4)^{18}$ to 1, or some 65,000 millions of times. Although this number can hardly be taken as it stands, yet this may, at any rate be said, that if the evidence obtained in 1877 gave an even chance or even a small degree of probability in favour of the conclusion that there is oxygen in the sun, the evidence of the present series of photographs makes this conclusion so exceedingly probable as to be practically certain. Professor Draper does not go quite so far as this, though he might

safely do so. "On the whole," he said, towards the close of the interesting paper which he read before the Astronomical Society on Friday, June 13, "it does not seem improper for me to take the ground that having shown by photographs that the bright lines of the oxygen-spark spectrum all fall opposite bright parts of the solar spectrum, I have established the probability of the existence of oxygen in the sun. Causes," he proceeded, "that can modify in some measure the character of the bright parts of the solar spectrum, obviously exist in the sun, and these, it may be inferred, exert influence enough to account for such minor differences as may be detected." In closing his paper, Professor Draper called attention to some points indicating the amount of labour and time his researches have already consumed. Each photograph demanded an exposure of fifteen minutes, and with preparation and development at least half an hour was needed. The making of a photograph, exclusive of experiments, required therefore about 30,000 10-inch sparks—that is, 30,000 revolutions of the bobbin of the Gramme machine. In the last three years the Gramme has made 20,000,000 of revolutions. The petroleum engine only consumes a couple of drops of oil at each stroke; and yet it has used up about 150 gallons. Each drop of oil produces two or three 10-inch sparks. "It must also be borne in mind," said Professor Draper, "that comparison spectra can only be made when the sun is shining, and clouds therefore are a fertile source of loss of time."

Mira Ceti.—This star reached its maximum about October 20 last. But an observation made by Mr. Greely of Boston, about three months before this time, would seem to show that there then occurred a well-marked though subordinate maximum. About the middle of August, Mr. Greely early in the morning, in looking for Saturn through the clouds, saw a star which he for a moment mistook for the planet; but its scintillations soon showed that it was not Saturn, but something unusual in that quarter of the sky. The clouds cleared off soon after, giving him an opportunity of noting its brightness, which he says was fully equal to that of any second magnitude star. Being curious to know what this star was, he carefully "memorized" its position (such is the expression used by Professor Sawyer of Cambridge, Mass., in describing Mr. Greely's observations)—the word memorize is not perhaps to be found in the dictionaries, but "'twill serve." On reaching home, Mr. Greely, by means of a star-chart, identified the star as being Mira. The next few nights were cloudy; and when he again saw the star it had greatly decreased in brightness, and shone as a fourth or fifth magnitude star. Professor Sawyer and Mr. Chandler (an observer of variable stars), were at first disposed to place little reliance on this singular observation, not questioning Mr. Greely's statements, but doubting if he had really identified Mira. Subsequent inquiries satisfied them however that he had. If the variations of Mira always followed the ordinary course described in the books, we could not very readily believe that on this particular occasion the star had deviated from its normal series of changes. But as a matter of fact abnormal phenomena have already been noted which tend to render Mr. Greely's statement far less improbable than it might otherwise be considered. Thus in the four years 1672 to 1676, Hevelius, though he searched specially for the star at the times when it should have shone with its maximum brightness (about that of a second magnitude star), failed altogether to detect it.

The Sadler-Smyth controversy.—The question to which we adverted in our last summary has not been dealt with precisely as the friends of the late Admiral Smyth could have wished. Instead of an examination of the singular instances of discrepancy from fact and agreement with the errors of others noticed by Messrs. Burnham and Sadler, which could not but have resulted either in clearing Admiral Smyth's memory from all suspicion, or else in showing that unfortunately the doubts which seem to be suggested by Mr. Sadler's recent paper were well founded, the matter has been simply dropped, the council of the Astronomical Society publishing a statement implying their regret that they ever allowed it to be taken up. A tone was adopted in discussing the matter which implied further, that whatever corrections may be made as to scientific statements, none which would suggest the possibility of fraud should ever be published. It was understood that this was specially urged by the Astronomer Royal, who being personally interested in the matter (not simply as a friend of Admiral Smyth's, but as having practically pledged himself to the value of Smyth's observations—now admitted to be almost valueless as a series) might perhaps with better taste have remained silent. But apart from this it was rather singular to hear the author of the most virulent personal attack recorded in the history of astronomy, that, namely, in which Father Hell was not only accused of bad and careless observation, but directly charged with personal fraud, adopting a tone which perhaps might have seemed correct enough, if rather affected, in the case of one who had never offended against propriety in such matters. We are glad, however, to find that Mr. Burnham emphatically accepts the interpretation placed by Mr. Proctor on the words "stupendous fraud," applied by Mr. Burnham to Admiral Smyth's work. He cannot understand, he says, how this could ever have been understood to imply personal fraud on the admiral's part; but herein we cannot quite agree with him, for in England that would be the natural interpretation of such an expression. But every one acquainted with American modes of expression, knew that the word "fraud," as used by Mr. Burnham, did not necessarily or even probably imply any personal reflection on the admiral, but simply indicated that his book was disappointing and unsatisfactory.

Spectrum of Brorsen's Comet.—The following observations of this interesting object have been made at Greenwich, and are communicated by the Astronomer Royal. The dispersion used was that of one compound "half-prism," equivalent to four flint prisms of 60° (20° from A to H), with a power of 12 on the viewing telescope. The spectroscope was mounted on the Great Equatorial.

The spectrum consists of the three usual cometary bands, corresponding to the three principal bands of the second spectrum of carbon, and does not present the anomalous appearance found by Dr. Huggins in 1868. The bands were compared on several evenings with those shown by a vacuum tube containing vapour of alcohol at a pressure of 1·2 m.m., and the coincidence appeared sensibly perfect.

The position of the brighest comet-band (in the green) was measured with Hilger's bright line micrometer on two evenings, April 19 and 28, by Mr. Maunder; on other occasions it was compared with the corresponding carbon-band indirectly by means of a movable bar in the eyepiece, 30 tenth-

metres broad. The following are the results of the micrometer readings for the less refrangible edge of the comet-band referred to the centre of the brightest portion of the carbon-band, which (with a narrow slit) is less than 5 tenth-metres broad:—

1879.	Comet-band.	Wave-length inferred.	Width of slit. in.
April 19	0·5 tenth-metres to blue	5190	0·009 = 16 tenth-metres.
28	4·5 „ to red	5191	0·013 = 24 „

The wave-length of the less refrangible edge of the carbon-band (alcohol vapour in a vacuum tube) has been taken at 5198·3 tenth-metres. As it was not found practicable to use a narrower slit, there is probably an uncertainty of several tenth-metres in the position of the comet-band, but it appears from these observations that it coincides approximately with the band in the second spectrum of carbon (vacuum tube) at 5198, and not with that in the first spectrum (blue flame of Bunsen burner) at 5165. On April 17 several comparisons were made by Mr. Christie, by bringing up a movable bar from the blue end of the spectrum so as just not to hide the bright edge of the comet-band, and in every case the coincidence of the less refrangible edges of the comet and alcohol-bands appeared sensibly perfect. In these observations the slit was of such a width that the bright line, with which the alcohol-band commences, had a breadth of about 30 tenth-metres. The principal comet-band extended about $\frac{2}{3}$ of the way towards F, to about wave-length 5,000, its blue end appearing to coincide approximately with a faint band of alcohol.

The second comet-band in the yellow was measured on April 28 by Mr. Maunder, and its red edge was found to be 2·4 tenth-metres to the red of the middle of the brightest part of the alcohol-band at 5610. The slit, however, was very wide, viz. $0^{in}·033$, corresponding to 65 tenth-metres. This measure would place the red edge of the comet-band at 5580, whilst the band in the first spectrum of carbon is at 5635. The more refrangible end of the yellow band appeared to coincide with a well-marked band in the alcohol spectrum. The third comet-band was very faint; it appeared to be in the neighbourhood of the blue band of alcohol at 4835. The relative brightness of the three bands was estimated thus: Green, 10; Yellow, 3; Blue, $\frac{1}{2}$.

At Lord Lindsay's observatory Dunecht, the following observations were made:—

1879, April 12, at $12^h\ 9^m$ S.M.T., the comet was well seen between clouds. It had a ray-like tail, which could be traced for about 25′ from the highly condensed nucleus. The coma was obviously elongated at right angles to the direction of the tail, its greatest diameter being about 5′. Clouds prevented further observations.

April 16, $10^h\ 30^m$ S.M.T., tail 10′ long, in position 57°·8 by six measures with powers 122 and 229. No structure could be detected in the nucleus with powers 229 or 312.

April 17, $12^h\ 56^m$ S.M.T., tail 13′ long, in position 51°·9 from three measures with power 122.

The spectrum was observed on April 16, May 2 and 3.

It consisted of three broad bands, the brightest parts of which had the following wave-lengths:—

	m.m.m.
No. 1	547·6
2	515·6
3	469·6

Nos. 2 and 3 were sharply bounded on the less refrangible side, fading off gradually towards the violet. No. 1 was very ill-defined on both sides, and, being without any definite brighter part, its wave-length is very uncertain. Observers, Ralph Copeland and J. G. Lohse.

Phenomena for the Quarter.—The sun will be eclipsed, but not visibly in England, on July 18. Venus will be at her greatest brilliancy, as an evening star, on August 19; and in inferior conjunction with the sun on September 24. Mercury will be in inferior injunction on August 24. Jupiter will be in opposition to the sun on August 31. Saturn (this however belongs to the following quarter) on October 5.

BOTANY.

The Black Mildew of Walls.—In "Science Gossip" for August last there was an article by Professor Paley, entitled "Is the Blackness on St. Paul's merely the Effect of Smoke," in which the author maintained that this blackness is chiefly due to the growth of an undescribed lichen, which appears to flourish only on limestone and in situations unaffected by the direct rays of the sun. Professor Leidy, calling the attention of the Academy of Natural Sciences of Philadelphia to this paper (September 3, 1878), remarked that he had himself many years ago noted a similar black appearance on the brick walls and granite work of houses in narrow shaded streets, especially near the Delaware River. Noticing a similar blackness on the bricks above the windows of a brewery, from which there was a constant escape of watery vapour, he was led to suspect that it was of vegetable nature. On examination it proved to be caused by an Alga, closely allied to what he regarded as *Protococcus viridis*, which gives the bright green colour to the trunks of trees, fences, and walls, usually on the shady side. It may be the same plant in a different state, but until this is proved he proposes to name it *Protococcus lugubris*. It consists of minute round or oval cells, from 0·006 to 0·009 millim. in diameter, isolated, or in pairs or groups of four, the result of division, or in short irregular chains of from four to a dozen, sometimes with a lateral offshoot of two or more cells.

Irritable or Sensitive Stamens.—In Part III. of the "Proceedings of the Academy of Natural Sciences of Philadelphia" for 1878, Mr. Thomas Meehan calls attention to the large number of plants now known which exhibit an irritative motion in some of their parts, and states that from his observations of plants of the orders *Bignoniaceæ*, *Scrophulariaceæ*, and *Acanthaceæ*, he has arrived at the conclusion that wherever there are bilobed flattened stigmas in these orders this sensitiveness to touch would be exhibited in a greater or less degree. He then remarks upon the fact that though in the *Opuntiæ*, a genus of *Cactaceæ*, the stamens move in various directions when

touched, yet no such motion had been observed in *Cereus*, *Mammillaria*, and other allied genera of the order; he had, however, noticed a similar motion in the stamens of the common garden *Portulaca grandiflora*, and in the Purslane, *Portulaca oleracea*. In another Portulaceous plant, *Talinum patens*, the expanded stamens fall down on the petals when touched, while, strangely enough, no trace of motion could be detected in *Talinum teretifolium*, though in a West Indian species which was found growing in a botanical garden in St. Louis the expanded stamens fell down on the petals when touched, and he thought it remarkable that this power should exist in *T. patens* and not in *T. teretifolium*.

Mr. Meehan suggests that the objects of these movements may yet form an interesting study, pointing out that in *Dionæa*, *Drosera*, and some others, the motion had been found to result in some immediate benefit to the plant; while in *Mimosa*, *Hedysarum*, and others, no such immediate benefit had been observed. In the case of sensitive stigmas, they had been supposed to have some reference to arrangements for cross-fertilization, but this he considered doubtful on these grounds:—In the case of *Mimulus ringens* the stigmas expand, and the anthers disperse their pollen before the corolla is quite open, and pollen may be generally found on the stigmatic surfaces when the mouth exposes these parts to view. In *Tecoma radicans*, on the other hand, the lobes of the pistil do not expand till some time after the mouth of the corolla is open, and in many cases pollen-hunting bees had carried away all the pollen before these lobes had expanded.

In cases where the expansion of the lobes and dispersion of the pollen were simultaneous, it was theoretically supposed that a bee or insect touched the lobes with its pollen-covered head or back, and that the lobes then closed against the admission of pollen on the withdrawal of the insect from the flower; but he had found that the bees in the cases observed by him occupied but from three to five seconds in visiting a flower, while it took from thirty to sixty seconds for the lobes to close, and then they were seldom so completely closed as to render the reception of fresh pollen difficult. Mr. Meehan had therefore come to the conclusion that the hypothesis in relation to cross-fertilization was untenable, and that the real use of this motion in the economy of nature still remained an open and promising field to the future investigator.

CHEMISTRY.

The Formation of Organic Ultramarines.—De Forcrand has already shown that the ultramarines of different metals may be obtained by allowing the chloride of the metal selected to act upon the silver ultramarine, and the idea occurred to him that the process might be extended to the chlorides or iodides of different alcoholic radicles. The silver compound was heated to 130° for from fifty to sixty hours with an excess of ethyl iodide. After the operation had gone on for from ten to fifteen hours the tube was opened, the product washed with alcohol, hyposulphite of soda, and water, and again placed in the tube with an excess of iodide. This process was repeated several times,

till, in fact, the carefully-washed product contained no more silver. The final product has a light grey colour, and is decomposed when heated, ethyl-sulphide being evolved. If it is previously strongly heated with sodium chloride no ethyl sulphide is given off, the grey powder turns blue, and the original ultramarine, with all its properties, is formed. In order to show that the ethyl really entered into the constitution of the ultramarine, the products of the action of heat on the body were collected in mercury chloride; the crystalline precipitate had the composition $(C_2H_5)_2S,H_gCl_2$, from which it is apparent that the ethyl actually formed a constituent. Similar reactions were observed with the iodides of other alcohol radicles and with some quaternary ammonium iodides.—(*Compt. rend.* lxxxvii. 30.)

Oxidation of Quinine with Potassium Permanganate.—According to the experiments of S. Hoogewerff and W. A. Van Dorp, during the oxidation of quinine by this method a part of the nitrogen is removed in the form of ammonia. Some oxalic acid is formed, as well as a nitrogenous base, which separates in transparent crystals, and melts at 244°. This new body is tribasic, and has the formula $C_8H_5NO_6$. A number of its salts have been prepared. Quinidin, as well as cinchonine, appears to furnish the same product when oxidized, and it appears to be tricarbopyridinic acid, $C_5H_2N(COOH)_3$.—(*Ber. chem. Gesell.* xii. 158.)

Lactucone.—N. Franchimont reports his having obtained a considerable quantity of lactucarium out of *Lactuca altissima*, from De Vrij, and his having induced Wigman to prepare the lactucone from it, and to compare it with betulin. He obtained it in the form of microscopic needles, insoluble in water, soluble with difficulty in alcohol, easily soluble in petroleum, and melting at 296°. Analysis pointed to the formula $C_{14}H_{24}O$, which does not accord with those adopted by Senior and Ludwig. An acetyl derivative could not be obtained; and phosphorus pentasulphide, by the withdrawal of water, left a hydrocarbon of the form $C_{14}H_{22}$. Lactucone appears to be homologous with camphor and the zeorine of Paterno.—(*Ber. chem. Gesell.* xii. 10).

Eikosylene.—This body is a derivative of the paraffin of coal tar. E. Lippmann and J. Hawliczek find that nearly all the paraffin met with in commerce contains oxygen. The specimens on which they operated were treated with sodium to remove it. To introduce chlorine into these purified products they employed phosphorus pentachloride, which was added to the solution of the paraffin in carbon tetrachloride, and heated with it. In this way a chloride having the formula $C_{20}H_{39}Cl$ was obtained, which, when distilled under ordinary atmospheric pressure, gave up its chlorine in the form of hydrogen chloride, the hydrocarbon to which they have given the name of eikosylene, and which has the formula $C_{20}H_{38}$, remaining isolated. It possesses all the characters of an olefine, and forms a second chloro-derivative, having the composition $C_{20}H_{38}Cl_2$. Eikosylene is consequently homologous with cetylene $C_{16}H_{30}$, and may be regarded as a high member of the acetylene series.—(*Ber. chem. Gesell.* xii. 62).

The Transformation of Starch into Dextrose in the Cold.—Starch, it is known, is slowly transformed into dextrose when boiled for a long time with water. Riban has made some observations which seem to show that the same result may be arrived at in the cold, though much more gradually. A

solution formed by boiling one part of finely-divided starch in one hundred of water saturated with salt, and filtering the same, is imputrescible, and may be preserved for a long time. After a year the author's solution appeared to be less sensitive to iodine, and after three or four years was no longer coloured by that reagent. It was neutral, limpid, contained no trace of any organized ferment, reduced the copper solution energetically, and was coloured brown by alkalies. Determined by the copper test, every 100 cc. contained 0·111 gramme of dextrose; but when ferrocyanide of potassium was employed, which is not affected by dextrin, 100 cc. contained 0·102 gramme. A mixture of nine-tenths dextrose and one-tenth dextrin was consequently formed from the starch. The solution in a tube 200 mm. long rotated to the right: $D\alpha = + 0{\cdot}15°$. The author calls attention to the importance of the transformation of starch in the cold without a ferment in its bearing on the physiology of vegetable growth.—(*Bull. Soc. Chim.* xxxi. 10).

The Action of Isomorphous Salts in Exciting the Crystallization of Supersaturated Solutions of each other.—Mr. John M. Thomson, of King's College, has read a paper on this subject before the Chemical Society (*Journ. Chem. Soc.*, May 1879). He points out that two explanations have been put forward to account for this action. One, that the crystallization is induced by the entrance of a particle of the same salt; and the other, that, a purely physical cause, such as the presence of greasy, fatty, or oily matter in thin films, may be found active in exciting the crystallization. A solution of potassium tri-iodide, which had remained under a desiccator for a considerable time without change, was found after a short exposure to the air to be filled with crystals of the tri-iodide. The solution had undergone supersaturation, and its deliquescent nature would most likely prevent its floating in the air as a solid: it obviously was not a particle of the salt itself which excited the crystallization. In his experiments the supersaturated solution was placed in a flask, and that of an isomorphous salt to be employed as nucleus in a thin glass bulb, which was supported in the neck of the flask with a plug of cotton wool. The solution in the bulb-tube having been boiled, the tube was stoppered with cotton wool. The contents of the flask were again boiled, and the arrangement placed aside for eighteen or twenty hours. To perform an experiment the solution in the bulb-tube was crystallized by touching it with a platinum wire, and the bulb-tube lowered into the liquid of the flask, allowed to remain there some time to see that the introduction of the glass into the fluid did not cause crystallization, and finally lightly broken in the fluid. Only a few examples of activity can be mentioned here. The action of isomorphous sulphates on magnesium sulphate was very successful. Zinc and nickel sulphate were active at once; cobalt and iron sulphate after some time; nickel sulphate with $6H_2O$, iron sulphate with xH_2O, and cobalt sulphate with xH_2O after some time. Sodium selenate with sodium sulphate crystallized immediately; chromium and iron alums with common alum were active. Hydrodisodic arsenate with the corresponding phosphate crystallized immediately and very rapidly. The experiments with the sulphates of nickel, magnesium, and zinc confirm the results of Gernez, published in 1866. The general results arrived at by Mr. Thomson are:—(A) When the mixture consists of two salts which are not isomorphous: (1) Sudden crystallization may take place, gradually spreading

through the solution on the addition of a nucleus, causing a deposition of the body belonging to the nucleus only; (2) That when sudden crystallization takes place, causing the deposition of both salts, there is a preponderance of the salt of the same nature as the nucleus; (3) That the nucleus may remain growing slowly in the solution, becoming increased by a deposition of the salt of the same nature as the nucleus. And (B) When the mixture consists of two isomorphous salts: (1) Sudden crystallization may occur giving a deposition of both salts, apparently in the proportion in which they exist in solution; (2) That when slow crystallization takes place, the nucleus increases by a deposition of the least soluble salt, showing that in mixed supersaturated solutions a gradation of phenomena may be experienced, passing from those shown in the crystallization of a true supersaturated solution to those shown in the crystallization of an ordinary saturated solution.

New Compounds of Ammonia and Hydrogen Chloride.—Hydrochloric acid and ammonia have hitherto been known only in one form of combination, that of sal-ammoniac, analogous to salt and potassium chloride. Troost, during his experiments on the vapour density of ammonia compounds, has found a number of curious compounds which dry ammonia forms with hydrogen chloride, sulphuretted hydrogen, and a number of other mineral and organic acids. In a recent communication to the Paris Academy of Sciences (*Compt. rend.* lxxxviii. 578) he describes two new compounds of ammonia and hydrochloric acid. The first contains four equivalents of ammonia and one of the acid; it melts at $+7°$, its crystals energetically depolarize light, and therefore do not belong to the same crystalline system as salammoniac; it is anhydrous and has the formula $HCl, 4NH_3$. The second compound contains seven equivalents of ammonia and one equivalent of the acid. It melts at $-18°$; the liquid exhibits all the characters of supersaturation; if rapidly cooled it becomes viscous; and at $-40°$ becomes a transparent solid mass. It has the composition $HCl, 7NH_3$.

GEOLOGY AND PALÆONTOLOGY.

Carboniferous Fenestellidæ.—Mr. G. W. Shrubsole has communicated to the Geological Society (February 21, 1879), the results of his investigations on the British Carboniferous Fenestellidæ. He finds that owing to neglect on the part of describers to allow for differences in the structure at various stages of growth and in different parts of the polyzoarium a great number of unnecessary species have been made; out the twenty-four recorded species of *Fenestellæ* he has examined nineteen, and his investigations lead him to reduce these to five.

Tertiary Fossils of Chili.—Descriptions of tertiary fossils from Chili have been given by various authors, especially D'Orbigny, G. B. Sowerby (in Darwin's "Geological Observations,") and Claude Gay. Dr. R. A. Philippi now publishes (*Zeitschr. für die gesammten Naturwiss.*, 1878), a notice of the forms contained in the Museum at Santiago, preliminary to a more detailed memoir, which will contain the descriptions of numerous new species. From the tertiary deposits of Chili and the dependent islands, he records a great

number of mollusca—1 Pteropod, 15 Gasteropoda, 188 Bivalves, and 5 Brachiopods—and species of *Nautilus* and *Baculites* also occur. Of other invertebrate groups Dr. Philippi notices Annelids, Echinoderms, and Zoophytes, or rather Bryozoa; whilst the vertebrata are represented by a few fish-remains, a *Plesiosaurus* and a whale. Of the eighty-one genera of mollusca, three, namely *Baculites*, *Cinulia*, and *Trigonia*, may be regarded as showing Cretaceous affinities, and the *Baculites* and *Plesiosaurus chilensis*, especially, have been regarded as more properly belonging to the Cretaceous series. Dr. Philippi has, however, obtained specimens of both species along with undoubted Tertiary fossils, and hence he is inclined to draw a parallel between the phenomena presented by this part of the geological series in Chili and in New Zealand, where, as is well known, Dr. Hector recognizes what he calls "Cretaceo-tertiary" strata. From the scarcity of forms proper to warm climates, and especially the absence of corals and Polythalamia, Dr. Philippi infers that at the period represented by these beds there may have been already a cold current flowing to this region from the Pole. An interesting point which comes out from his table of the molluscan genera is that the tertiary fauna of Chili possessed a much greater similarity to the existing fauna of the Mediterranean than to that of the neighbouring coasts. It included at least twenty-five important genera, now entirely wanting on the Chilian coast, but all, with the exception of *Perna*, represented in the Mediterranean.

Among the remains of fish, which are generally so fragmentary as to be incapable of determinination, Dr. Philippi records the discovery of the tooth of a species of *Carcharodon*, which is interesting from its relationship to the gigantic teeth belonging to the same genus found in the Tertiaries of the Mediterranean region. The author describes it as belonging to a distinct species under the name of *Carcharodon gigas*; it differs from the well-known *Carcharodon megalodon* at first sight by its obliquity; its convex side is obtusely ridged, and its margins are less regularly and less deeply notched than those of the European species. The length of the longer margin of the tooth was about $4\frac{1}{4}$ inches.

Polydactyle Horses.—Professor Marsh has an article on this subject in the "American Journal" for June 1879, which, besides describing his observations on recent horses with supplementary digits, gives an interesting summary of the palæontological facts bearing on the question of the supposed parentage of existing Solidungulates. It appears that the most common form of polydactylism in living horses is the presence of an extra small toe and hoof on the inside, either of the anterior pair or of all four feet, but Professor Marsh has lately heard of a colt with three toes on one fore foot and two on the other, and of a mare (still living) which has three toes on each fore foot and a small extra digit on each hind foot. The more frequent presence of extra digits on the fore foot is what might be expected; but the abnormal development of the toe on the inside is curious, both because in general the second digit is less persistent than the fourth, and because, when developed, it would seem to be rather in the way.

Of the American series of precursors of the horse, Professor Marsh speaks as follows: "If we examine the remains of the oldest representatives of the horse in this country, we shall find that these animals were all polydactyle

and of small size. As the line was continued towards the present era, there was a gradual increase in size, and a diminution in the number of toes, until the present type of horse was produced. . . . . The original ancestor of the horse, not as yet discovered, undoubtedly had five toes on each foot. The oldest member of the group now known is the *Eohippus*, which had four well-developed toes and the rudiment of another on each fore foot, and three toes behind. This animal was about as large as a fox, and its remains are from the Coryphodon beds, near the base of the Eocene. In the next higher division of the Eocene, another equine genus, *Orohippus*, makes its appearance. It resembled its predecessor in size, but had only four toes in front, and three behind. At the top of the Eocene, a third allied genus has been found (*Epihippus*), which closely resembled *Orohippus* in its digits, but differed in its teeth. Near the base of the next formation, the Miocene, another equine mammal (*Mesohippus*) occurs. This animal was about as large as a sheep, and had three usable toes, and the splint of another, on each fore foot, with but three toes behind. At a somewhat higher horizon, a nearly allied genus (*Miohippus*) has been found, which has the splint, even of the outer or fifth digit, reduced to a short remnant. In the Pliocene above, a three-toed horse (*Protohippus*), about as large as a donkey, was abundant; and still higher up a near ally of the modern horse, with only a single toe on each foot (*Pliohippus*), makes his appearance. A true *Equus*, as large as the existing horse, appears just above this horizon, and the series is complete." These remarks are illustrated with an interesting series of figures showing the structure of the fore and hind feet, the fore-arm, the leg, and the upper and lower molars in each genus.

A Moravian Cave.—In an article communicated to the Academy of Sciences of Vienna, Dr. K. T. Liebe notices the contents of the cavern of Vijpustek, near Kiritein, in Moravia. The bones of Mammalia found in this cave represent the following species:—*Lynx vulgaris* (lynx), *Felis Catus* (wild cat), *Canis spelæus* (Diluvial wolf), *Canis familiaris* (dog), *Vulpes vulgaris* (fox), *V. lagopus* (Arctic fox), *Gulo borealis* (glutton), *Martes abietinum* (pine martin), *Fœtorius putorius* (polecat), *F. erminea* (ermine), *Vesperugo serotinus* (Serotine bat), *Arvicola* sp. (vole), *A. amphibius* (water-rat), *Lepus variabilis* or *timidus* (mountain hare), *Cricetus frumentarius* (hamster), *Myoxus Glis* (dormouse), and *Sciurus vulgaris* (squirrel). Dr. von Hochstetter states that besides these seventeen species the cave contains remains of *Elephas primigenius* (mammoth), *Rhinoceros tichorhinus* (woolly rhinoceros), *Equus fossilis* (horse), *Bos priscus* (aurochs), *Cervus tarandus* (reindeer), *C. capreolus* (roe-deer), *C. eurycercus* (?), *Capra Ibex* (ibex), *Ursus spelæus* (cave bear), *Felis spelæa* (cave lion), and *Hyæna spelæa* (cave hyæna), so that twenty-nine species of mammals are known from the cave.

A comparison of these bones with those obtained from the caves of Thuringia leads to some interesting results. It is clear that the cave of Vijpustek was a den occupied for long periods, now by families of hyænas, now by families of bears, and occasionally visited by cave lions, wolves, and lynxes; whilst its numerous side-galleries, some of which probably opened directly into the outer air, harboured smaller beasts of prey, such as the polecat, marten, and glutton. A few animals, indeed, may have been floated as carcasses into the cave; but the greater part of the remains are those

either of animals which inhabited it and died in it, or of such as were dragged in as prey by these residents. The whole fauna of the cave is essentially a forest fauna, proving that in later diluvial times its neighbourhood was forest-clad; whilst the investigation of the Thuringian caves and other deposits of the same period in North Germany show equally clearly that the whole of that country was then a naked steppe quite destitute of forests. Hence it would appear that the mountainous and hilly country of southern Bohemia and Moravia was the starting point from which the primeval forest spread over the great diluvial steppe of Central Europe north of the Alps.—(*K. Akad. Wiss. Wien*, 23rd May, 1879.)

An Anthropoid Ape in the Siwáliks.—Mr. Lydekker announces the discovery by Mr. Theobald of the upper jaw and palate of a large anthropoid ape in the Siwáliks of the Punjab. It belonged to a female animal, judging from the small size of the canines, and indicates a creature intermediate in size between the orang and the gorilla. The molars are of the ordinary anthropoid type; but the premolars are much narrower than in any known anthropoid ape, and indeed relatively narrower than even in man; and the small size of the last molar and of the incisor are also points giving the jaw a human character. The chimpanzee, of living apes, comes nearest to this fossil. The specimen is of great interest as being the first trace of the large anthropoid apes found in India, and from its resemblance to the chimpanzee and gorilla, the great apes of Western Africa.—*Proc. Asiat. Soc. Bengal*, December 1878.

The Glaciation of the Shetland Isles.—On March 26 Messrs. Peach and Horne communicated to the Geological Society an elaborate paper on the Shetland Isles, in which they described the different islands, reviewing in succession the physical features, geological structure, the direction of glaciation, and the various superficial deposits. From an examination of the numerous striated surfaces, as well as from the distribution of Boulder-clay and the dispersal of stones in that deposit, they inferred that during the period of extreme cold Shetland must have been glaciated by the Scandinavian Mer de Glace, crossing the islands from the North Sea towards the Atlantic. In the island of Uist, blocks of serpentine and gabbro are found in the boulder-clay on the western shores derived from the rock-masses occurring on the east side of the watershed. Moreover, on the mainland between Scalloway and Fitful Head, blocks derived from the Old-Red-Sandstone formation on the eastern sea-board are abundant in the Boulder-clay on the west side of the watershed. The relative distribution of these stones in the sections on the west coast is in direct proportion to the relative areas occupied by the rocks on the east side of the watershed. It was likewise pointed out that after the period of general glaciation Shetland nourished a series of local glaciers which radiated from the high grounds, the direction of the striæ being at variance with the older system, while the morainic deposits also differ in character from the Boulder-clay produced by the great Mer de Glace.

The authors described the order of succession in the Old-Red-Sandstone formation in Shetland, and referred to the discovery of an abundant series of plant-remains in rocks which have hitherto been regarded as forming part of the series of ancient crystalline rocks. The plant-remains are identical with

those found in the Old-Red-Sandstone rocks in Caithness, Orkney, and Shetland, from which it was inferred that the quartzites and shales in which the fossils are imbedded must be classed with this formation. The authors also described the great series of contemporaneous and intrusive igneous rocks of Old-Red-Sandstone age, adducing evidence in proof of the great denudation which has taken place in the members of this formation in Shetland.

A Silurian Area near Cardiff.—Mr. Sollas described to the Geological Society, on April 9, the occurrence of unmistakable Silurian rocks about Rhymney and Pen-y-lan, near Cardiff. They comprise beds belonging to the Wenlock and Ludlow groups, and pass conformably upwards into the Old Red Sandstone. The district affords a good base for a measurement of the thickness of the Old Red Sandstone on the south of the South Wales coalfield. This was found to be a little over 4,000 feet. The thinning out of the Old Red Sandstone and Silurian strata, together with the marked change which takes place correspondingly in the lithological characters of the latter formation on passing from the north to the south side of the coalfield were taken to indicate an approach to a shore-line. This shore-line belonged to land which, as shown by the great thickness of the Devonian beds, could not have extended far south. It corresponded to Mr. Etheridge's barrier between the Old Red Sandstone and Devonian seas. The sandstones with Old-Red characters, such as the Hangman Grit and the Pickwell-down Sandstones, occurring in the Devonian formation, were deposited at intervals when this barrier was submerged to a greater depth than usual. The Cornstones were stated to thin out to the south along with the other sedimentary beds of the Old Red Sandstone, and were regarded as derived from the denudation of previously upheaved limestones, such as the Bala and Hirnant. The paper concluded with a description of the characters of the more interesting rocks and fossils.

Were Ichthyosaurs Viviparous?—Professor H. G. Seeley laid before the Geological Society at its last meeting the evidence which seemed to him to show that certain species of *Ichthyosaurus* might possibly have produced living young. He described several specimens in which the remains of one or more small individuals have been preserved within the body-cavity of larger ones. One of these was described and figured in 1822, by Jäger; a notice of another was published in 1846 by Dr. Chaning-Pearce, who suggested that it furnished evidence in favour of the viviparity of the Ichthyosaurs. Other examples are preserved in museums in Germany, and one in Madrid, and most of them have been examined by the author, who adduces the state of preservation of the small individuals, in contrast with that of the traces of fish and Cephalopoda, the remains of food, which are found in the stomachal region of the larger individuals, in advance of the position occupied by the smaller ones, as a proof that we have not here to do with a case of cannibalism. The position of the smaller skeletons with the head generally turned towards the pelvic region of the larger ones is also regarded as indicative of their standing in the relation of parent and offspring. As some of the young specimens possess limbs it would seem that the supposition that the Ichthyosaurus passed through a sort of tadpole stage is erroneous. It must be observed, however, that, as we are entitled *à priori* to assume that the Ichthyosaurs, if they produced living young, were

merely ovo-viviparous, after the fashion of those reptiles of the present day whose offspring are brought into the world alive and free, the large size of some, at least, of the young examples cited by Professor Seeley is hardly reconcilable with the idea of their embryonic condition.

A New Type of Pterodactyles.—At the last meeting of the Geological Society Professor Seeley described the characters presented by the impression of the skull of an Ornithosaur in a slab of Stonesfield-slate from Kineton near Stow-on-the-Wold, the peculiarities of which are such as to induce him to found for it a new genus, to which he thinks it probable that most, if not all, the known Stonesfield-slate Pterodactyles may belong. It is distinguished especially by the great length of the roof of the skull posterior to the orbits, by the presence of a very deep constriction of the frontal region between the orbits, by the strongly marked sutures between the bones, and by the curiously crocodilian character of the plan of structure of the roof of the skull, which suggests the existence of a lower grade of Ornithosaurian animals than has hitherto been suspected. The genus appears to be allied to some forms of *Rhamphorhynchus*. The author names the species, which is in the Oxford Museum, *Rhamphocephalus Prestwichi*, and considers that the other bones of Ornithosauria discovered in the Stonesfield Slate support the generic separation of the group.

New Fossil Crustacea.—On May 28, Dr. Henry Woodward communicated to the Geological Society descriptions of four new Fossil Crustacea possessing considerable interest. Three of them are regarded as Stomapods of the family Squillidæ, and one of these is especially interesting, if correctly referred to that group, as carrying back the Squilliform Crustacea in time to the middle Coal-measures. The specimen was found by Mr. E. Wilson, of Nottingham, in a nodule of Clay-ironstone from Corsall, near Ilkeston, in Derbyshire, but is, unfortunately, very imperfect, consisting only of the four posterior abdominal segments and the telson. Dr. Woodward names it *Necroscilla Wilsoni*, and thinks it probable that it is allied to the genus *Diplostylus*, Salter, from the Coal-measures of the Joggins, Nova Scotia.

A true *Squilla* was described under the name of *Squilla Wetherelli* from a specimen preserved in a phosphatic nodule of the London Clay of Highgate, forming part of the late Mr. Wetherell's collection. It is of interest from its resemblance in characters to the existing species of the family, its nearest ally being a recent Australian species, unnamed, but related to the well-known *Squilla Desmarestii*.

A second *Squilla*, this time from the Cretaceous deposits of the Lebanon, is also most nearly related to the Australian species above-mentioned, the segments not being ornamented with spines and ridges as in most recent forms. The specimen occurs in a collection made by Professor E. R. Lewis, of Beirût, consisting chiefly of the remains of fishes preserved in a compact cream-coloured limestone. It was named *Squilla Lewisii*. In the same collection there was the most interesting of all the species described by Dr. Woodward on this occasion, namely, a fossil king crab (named by the author *Limulus syriacus*), well-preserved in a slab of the same cream-coloured limestone. From a palæontological point of view the discovery of this new king crab is very important, as it helps to bridge over the gap previously intervening between the Jurassic *Limuli* of Solenhofen and those of our present seas.

Iguanodon in the Kimmeridge Clay.—Professor Prestwich announces (*Geological Magazine*, May 1879) a most interesting discovery which has lately been made at Cumnor Hurst, near Oxford. The workmen engaged in the brickfield there found, in digging, a quantity of bones, which they brought to the Museum at Oxford, and which, on being cleaned, displayed the characteristic peculiarities of *Iguanodon*. Many of the vertebræ are entire; the jaw, although in fragments, contains many teeth in position; and one of the feet, with the claw-joints, is almost complete. The larger bones are nearly all broken; but many of them may probably be united, and it is believed that the skeleton was nearly complete when found. The animal is smaller than the Wealden *Iguanodon Mantelli*, and may perhaps be a young individual of that species, but Professor Prestwich is inclined to regard it as a distinct species, with smaller and more delicately formed bones. On visiting the spot, Professor Prestwich learned that the bones had been found in a seam of yellow sandy clay two or three inches thick, at a depth of about four feet, and the clay above this seam contained perfectly characteristic Kimmeridge Clay shells, such as *Exogyra virgula*, *Cardium striatulum*, *Thracia depressa*, and *Ammonites biplex*, with *Lima pectiniformis* and *Serpulæ*. Hence it would appear that *Iguanodon*, or some closely allied Dinosaur, was not confined to the Lower Cretaceous and Wealden periods, but existed also during that of the Kimmeridge Clay.

MINERALOGY.

The Presence of Didymium and Cerium in Minerals.—As Horner has shown the presence of these metals in different pyromorphites and scheelites by aid of the spectroscope, so Cossa has now recognized them in apatites, scheelites, osteolites, and coprolites, not only by means of the spectroscope, but by separating them in the form of oxalates. He has also found the cerium metals in marble and in bones. From a kilogramme of Carrara marble two centigrammes of cerium oxalate were obtained. The muschelkalk of Avellino is found to contain still larger quantities of cerium compounds. A kilogramme of washed bone ashes, such as is used for the formation of cupels, yielded three centigrammes of cerium oxalate. These observations go to show that the cerium metals are widely spread throughout nature. Cossa is at present occupied with an examination of natural phosphates and the ashes of plants.—(*Ber. chem. Gesell.* xi. 1837.)

Artificial Formation of Nepheline and Leucite.—We some time since directed attention to the method employed by F. Fouqué and A. Michel Levy to form felspars artificially. By the same method they have recently prepared the minerals above mentioned. Nepheline is formed when a mixture of silicic acid, alumina, and sodium carbonate, in such proportions that the oxygen of protoxide, sesquioxide and acid are as 1 : 3 : 4, are heated together; white silk-like crystals are obtained which under the microscope are seen to be small hexagonal prisms (they are 0·12 min. long, and 0·06 min. broad), which accord in every respect with natural crystals of nepheline. If somewhat more silicic acid be taken, like that corresponding to the proportion 1 : 3 : $4\frac{1}{2}$, a completely crystalline mass is obtained, which bears in its optical

characters the same resemblance to hexagonal nepheline as chalcedony does to quartz. By melting together one-tenth pyroxene and nine-tenths nepheline a mixture of four different minerals was obtained: nepheline, pale green spinel, garnet in brown-yellow octahedra, and microlite. Leucite was also found in the fused product, and resembled both in form and optical characters the natural mineral.—(*Compt. rend.* lxxxvii. 961.)

The Supposed Native Iron of Greenland.—The Academy of Sciences of Paris appointed a commission to report on a paper by Dr. L. Smith on the "Supposed Native Iron of Greenland," and their report has recently been presented by M. Daubrée. It is pointed out that the bodies which come from beyond our atmosphere, and which are called meteorites, present as regards their mineralogical constitution a most striking resemblance to certain terrestrial rocks. The important fact that masses derived from most widely separated regions of space should present such resemblance was pointed out by Nordenskjöld in 1870, when he discovered large masses of native iron at Ovifak, on the Island of Disco. The first thought which suggested itself to him was that they were of meteoric origin. In order to explain the fact that these masses were forced into the basalt, he assumed that they had fallen into it while it was still liquid. Many adopted this view, and among others Nauckhoff and Tschermak. Steenstrup, on the other hand, after visiting the locality twice, came to the conclusion that they were masses of native iron, and that they had the same terrestrial origin as the basalt itself. Not far from Ovifak in the Waigatstrasse, Steenstrup found evidence which supported his theory: in the basalt of Igdlokungoak he hit upon a large mass of nickeliferous magnetic pyrites weighing about 28,000 kilogrammes, and again in the basalt of Aussuk small grains of native iron. The graphite associated with this iron pointed to the probability that carbonaceous substances had reduced this metal; moreover the rock enclosing the native iron also contained some of the ferric hydrated silicate which has received the name of hisingerite. With these opposing views, so plainly set forth, Dr. L. Smith has gone over the whole question, and comes to the same conclusion as Steenstrup, that the masses of metal are of terrestrial origin. He finds that in the dolerite of Aussuk, as well as that of Ovifak which it closely resembles, metallic iron is found enclosed in labradorite; anorthite is likewise found in certain parts of the mass of the rock and oligoclase also. Iron has been obtained from seven localities in Greenland: from Sowallicke, Fiskenäs, Niakornak, Glück's Bay, Jacobshavn, Ovifak, and Aussuk. The irons of Sowallicke and Niakornak are found by Dr. L. Smith to contain combined carbon just as the Ovifak iron does; in fact, he states that all specimens of iron obtained from Greenland are similar in this respect, and differ from meteoric iron which contains no combined carbon; moreover these masses all contain cobalt in considerable quantity in relation to the nickel. Dr. Smith next refers to the similar geological character of the area where the irons have been met with, it being found only in the basalt region, which extends from 69° to 76° where it disappears under a large glacier. We shall probably never know how wide the extent is of this volcanic area which stretches far away north; that, however, which has been seen represents an area equal to one extending from Gibraltar to Brest. We know that the rocks which present the greatest resemblance to

the meteoric rocks belong to the lowest beds of the earth. Some are eruptive rocks of basic character consisting of anorthite and augite, like certain lavas from Iceland; others are olivinous rocks, like lherzolite, to which the meteorites containing magnesia—those, in fact, of the ordinary type—belong. The presence of olivinous rocks accompanying the platinum of the Urals, and the presence of nickel in the iron combined with platinum, have confirmed these relations, which are of interest to both the geologist and the astronomer. It was expected that among the aluminous and magnesian rocks some might be found in which iron should begin to make its appearance, and this gap has now been filled. In the Greenland beds layers of lignite are found associated with the basalt, and this may have furnished the material which has reduced the iron to the metallic state.—(*Compt. rend.* lxxxvii. 911.)

Fairfield County Minerals.—G. J. Brush and E. S. Dana have published a second paper on the minerals of Fairfield County, Connecticut, in the "American Journal of Science," May, 1879. In the present paper they describe a new mineral which they name *fairfieldite*. It occurs in massive crystalline aggregates, rarely in distinct crystals. It has a hardness 3·5, and the specific gravity 3·25, a subadamantine lustre, and is white or of a pale straw colour. The streak is white and the substance itself transparent. It occurs in small particles in fillowite (described beyond) and in masses of some size immediately associated with eosphorite, triplcidite, and dickinsonite. The crystals belong to the triclinic system. The analyses closely accorded with the numbers:

Phosphoric acid	39·30
Iron protoxide	6·64
Manganese protoxide	13·10
Lime	30·99
Water	9·97
	100·00

which correspond with the formula $3RO,P_2O_5,H_2O$, where R = Ca : Mn + Fe = 2 : 1, and the ratio of Mn : Fe is also 2 : 1. Fillowite occurs in granular crystalline masses which are not unfrequently penetrated by distinct prismatic crystals of triploidite, and sometimes enclose particles of fairfieldite. Reddingite is very commonly associated with fillowite, and in many cases it is not easy to distinguish the two minerals. The hardness is 4·5, and the specific gravity 3·41–45. The lustre is subresinous to greasy; the colour generally wax-yellow, also yellowish to reddish-brown, with a red or green tinge, and rarely almost colourless. The crystals have a marked rhombohedral aspect; the measurements, however, point to a monoclinic form, and that this is the true explanation was proved by the subsequent optical examination. The results of the analyses of this mineral nearly accord with the numbers given below:

Phosphoric acid	40·19
Iron protoxide	6·80
Manganese protoxide	40·19
Lime	5·28
Soda	5·84
Water	1·70
	100·00

which are those corresponding with the formula $3R_3P_2O_8 + H_2O$, if in this formula R = Mn : Fe : Ca : Na = 6 : 1 : 1 : 1. A small amount of water was met with even in the most transparent specimens. If the water were not essential, the composition of the mineral would be somewhat analogous to that of triphyllite, containing sodium in place of lithium.

A Titaniferous Chrysolite.—M. Damour has described a titaniferous chrysolite from Zermatt, Switzerland. (*Bull. Soc. Min. Franc.*, ii. 15.) It has a red colour similar to that of almandine garnet, and the specific gravity 3·27. Analysis shows it to consist of silicic acid 36·14; titanic acid 6·10; magnesia 48·31; iron protoxide 6·89; manganese oxide 0·19; and loss by ignition 2·23. Total = 99·86. This gives almost exactly the required ratio 1 : 1 for bases to silicon.

PHYSICS.

Rotation of the Plane of Polarization by Electro-Magnetism in a Vapour. MM. Kundt and Rontgen have communicated their results on this subject to the Munich Academy. They have proved the fact of such rotation, which Faraday failed in demonstrating, at least in the vapour of sulphide of carbon. This substance was chosen for experiment because it shows strong electro-magnetic rotation in the liquid state, and because its vapour has great tension, even at moderate temperatures. An iron tube, closed at the ends by thick glass plates, was enclosed in an outer tin tube through which steam at 100° Cent. could be passed. The outer tube was surrounded by six large coils of wire, containing 400 turns of thick wire each, through which a current from 64 large Bunsen elements was passed. Sulphide of carbon vapour was heated as above described, and at the temperature of boiling water the vapour became transparent. A beam of polarized light was passed through the tube, and analysed by Nicol's prism. On the current being sent, a distinct brightening of the field was observed, which increased if, after rotating the prism afresh to darkness, the current was reversed. The rotation was in the direction of the positive current through the coils, and amounted to about half a degree. Sulphuric ether similarly treated gave no result. The authors of the paper are making apparatus by means of which to examine permanent gases and unsaturated vapours, with the special view of ascertaining whether oxygen rotates the plane of polarization in the same direction as other gases. Monsieur E. Bichat contributes a memoir to the "Comptes Rendus" of the Academy, in which he states that he has been following out a similar series of experiments since July 1878, which give very different results from those noted above. He points out that the iron tube used by the German physicists very materially injures the completeness of the action. It is in reality a hollow electro-magnet; whereas his tube being of brass allows the whole force of the current to expend itself on the contained vapour. In illustration of the difference, he passes a tube containing liquid bisulphide of carbon through the two poles of an electro-magnet, obtaining a rotation of 10° 30′; but on using a single hollow core with the same current, no appreciable rotation is obtained. If the iron tube be thin, the action is not entirely annulled, but

is considerably diminished—in the instance he gives from 5° to 1°. With his apparatus he has followed from zero to boiling point the rotation of the same current in sulphide of carbon and bichloride of tin. The molecular rotatory power is maintained as long as the boiling point is not approached. At that moment there is a diminution much more rapid than could have been foreseen from calculations based on the ratios of density.

A Mirror Barometer.—M. Leon Tesserenc de Bort has ingeniously modified the common aneroid barometer by substituting for the train of clockwork terminating in a pointer a mirror mounted on a jewelled axis, which is rotated by the rise and fall of the exhausted receiver, and its indications read off by a small telescope by reflection from a graduated scale. The sensibility of the instrument is said to be much increased, and all errors due to a long train of wheelwork are eliminated.

Influence of Electricity on Colliding Water Drops.—Lord Rayleigh communicates a paper to the Royal Society on this subject. It has been long known that electricity has great influence on fine jets of water ascending in a nearly vertical direction. In its normal state a jet resolves itself into drops, which even before passing the summit of the column, and still more after passing it, are scattered to a considerable width. When a feebly electrified body is brought into the neighbourhood of the jet, it undergoes a remarkable transformation, and appears to become coherent; under more powerful electrical action the scattering becomes more marked than at first. The latter action is due to mutual repulsion of the drops; the former has been hitherto unexplained. The cohesion seems to be more apparent than real; the seat of sensitiveness is at the place of resolution into drops: each drop carries away with it an electric charge, which can be collected in an insulated receiver. He is able to show that the normal scattering is due to the rebound of the colliding drops; such collisions being inevitable in consequence of the different velocities acquired by the drops under the action of capillary force, as they break away irregularly from the continuous portion of the jet. When the resolution is regularized by the action of external vibrations, as in Savart's and Plateau's experiments, the drops must still come into contact as they reach the summit of their parabolic path. Under moderate electrical influence, instead of rebounding after collision, they coalesce, and the jet is not scattered. This behaviour of the drops becomes apparent under instantaneous illumination, such as that of an induction coil, into the secondary circuit of which a Leyden jar is introduced. To obtain further evidence two similar jets were made to collide horizontally, one being in communication with the earth, the other supplied from an insulated cistern. The sensitiveness to electricity was extraordinary. A piece of rubbed gutta-percha brought near the insulated bottle at once determined coalescence. It was also possible to cause the jets again to rebound from one another, and then to coalesce.

Besides statical electricity, the electro-motive force of a single Grove cell was sufficient to produce the same phenomena, one pole being connected with the water, the other to earth. Even the discharge of a condenser charged by a single Grove cell answered the purpose. The writer indicates in conclusion the probable application to meteorology of the facts mentioned. The formation of rain must obviously depend materially on the consequences

of encounters between cloud-particles. If the contacts result in coalescence the drops must rapidly increase in size and be precipitated as rain. We may thus anticipate an explanation of the remarkable but hitherto mysterious connection between rain and electrical manifestations.

Influence of Pressure on Spectra.—Herr Ciamician has contributed experiments on this subject to the Vienna Academy. The spectra of chlorine, bromine, and iodine show the same peculiarities under increased pressure; the bright lines becoming broader, but not spreading into bands, a continuous illuminated background appears which often overpowers the lines. The spectrum of sulphur does not change at all, neither does that of phosphorus and arsenic.

Metals behave very differently. Here a real band-like extension of the spectral lines takes place, while the continuous light remains subdued. In the mercury spectrum the enlargement of the green and violet lines is specially noteworthy. In the sodium spectrum the enlargement is very considerable, but can only be observed with the reversed or dark D line. Under high pressure sodium gives a continuous background in the immediate neighbourhood of the D line upon which the reversed line appears. The double line gradually merges into one, becoming wider until it finally covers the whole background.

The Induction Balance and Sonometer.—Professor Hughes read a most important paper on these remarkable instruments before the Royal Society on May 15. After noticing Arago's original discovery of the action of rotating plates upon a magnetic needle, as well as Babbage's, Herschel's, and Dove's experiments, he remarked that in the microphone and telephone an instrument of extreme sensitiveness to minute induced currents had been obtained, and already published by him. In continuing the inquiry, the idea occurred to him that he might again investigate the molecular constructions of metals and alloys; and with this object has obtained, after numerous comparative failures, a perfect induction balance, which is not only exquisitely sensitive and exact, but allows us to obtain direct comparative measures of the force or disturbances produced by the introduction of any metal or conductor.

The instrument presented to the Royal Society consisted—1st, of new induction-currents balance; 2nd, microphone, with a clock as a source of sound; 3rd, electric sonometer, or absolute sound measurer; 4th, a receiving telephone and three elements of Daniells' battery.

In order to have a perfect induction-currents balance suitable for physical research, all its coils, as well as the size and amount of wire, should be equal. The primary and secondary coils should be separate, and not superposed. The exterior diameter of the coils is $5\frac{1}{2}$ centims., having an interior vacant circular space of $3\frac{1}{2}$ centims.; the depth of the flat coil or spool is 7 millims.

Upon this box-wood spool are wound 100 metres of No. 32 silk-covered copper wire. Four of such coils, formed into two pairs, are used, the secondary coil being fixed permanently, or by means of an adjustable slide, at a distance of 5 millims. from its primary; on the second similar pair there is a fine micrometer screw, allowing the adjustment of the balance to the degree of perfection required.

These two pairs of coils should be placed at a distance not less than 1 metre from each other, so that no disturbing cause should exist from their proximity.

The two primary coils are joined in series to the battery, the circuit also passing through the microphone.

The telephone is well adapted as an indicator, but not as a measurer of the forces brought into action. For this reason he has joined to this instrument an instrument to which he has given the name of electric sonometer. This consists of three coils, similar to those already described, two of which are placed horizontally at a fixed distance of 40 centims. apart, and the communication with the battery is so arranged that there are similar but opposing poles in each coil; between these there is a coil, which can be moved on a marked sliding scale divided into millimetres, in a line with these two opposing primary coils; the centre coil is the secondary one, and connected by means of a circuit changing key with the telephone in place of the induction balance. If this secondary coil is near either primary coil, we hear loud tones, due to its proximity. The same effect takes place if the secondary coil is near the opposing coil, except that the induced current is now in a contrary direction, as a similar pole of the primary acts now on the opposite side of the induction coil; the consequence is, that as we withdraw it from one coil approaching the other, we must pass a line of absolute zero, where no current whatever can be induced, owing to the absolute equal forces acting equally on both sides of the induction coil. This point is in the exact centre between the two coils, no matter how near or distant they may be. We thus possess a sonometer having an absolute zero of sound; each degree that it is moved is accompanied by its relative degree of increase; and this measure may be expressed in the degrees of the millimetres passed through, or by the square of the distances in accordance with the curve of electro-magnetic action.

If we place in the coils of the induction balance a piece of metal, say copper, bismuth, or iron, we at once produce a disturbance of the balance, and it will give out sounds more or less intense on the telephone according to the mass, or if of similar sizes, according to the molecular structure of the metal. The volume and intensity of sound is invariably the same for a similar metal. If by means of the switching key the telephone is instantly transferred to the sonometer, and if its coil be at zero, we should hear sounds when the key is up or in connection with the induction balance, and no sounds or silence when the key is down or in connection with the sonometer. If the sonometer coil were moved through several degrees, or through more than the required amount, we should find that the sounds increase when the key is depressed; but when the coil is moved to a degree where there is absolute equality with the key up or down, then the degree on scale should give the true value of the disturbance produced in the induction balance; and this is so exact that if we put, say, a silver coin whose value is 115°, no other degree will produce equality. Once knowing, therefore, the value of any metal or alloy, it is not necessary to know in advance what the metal is, for if its equality is 115°, it is silver coin; if 52, iron; if 40, lead; if 10, bismuth; and as there is a very wide limit between each metal, the reading of the value of each is very rapid, a few seconds sufficing to give the exact sound value of any metal or alloy.

The Audiometer was exhibited by Dr. Richardson at the meeting of the Royal Society on May 22. It consists of two Leclanché's cells; a new microphonic key connected with the cells, and with two fixed primary coils; and a secondary or induction coil, the terminals of which are attached to a telephone. The induction coil moves on a bar between the two fixed coils, which is graduated into 200 parts, by which the readings of sound are taken. The scale is divided into 20 centims., and each part is subdivided into 10, so that hearing may be tested from zero to 200. The fixed coil on the right hand contains 6 metres of wire; that on the left hand contains 100 metres. The secondary coil contains 100 metres of wire.

In using the instrument, the induction coil is moved along the scale from or towards the larger primary as may be required, and the degrees or units of sound are read from the scale, the sound being produced by the movement of the microphonic key between the battery and the primary coils.

As a rule, the hearing of right-handed persons is most refined in the right ear. The influence of atmospheric pressure is to be detected by this instrument, the delicacy of hearing diminishing when the barometer is low. The effect of practice and of memory in distinguishing sounds has also been experimented on.

The Sphygmophone.—It occurred to Dr. B. W. Richardson, while experimenting with the audiometer, that he might get a secondary or telephonic sound from the movements of the pulse at the wrist. He effected this in a very simple manner, by adding a microphone to a Pond's sphymograph. He mounts on a slip of talc a thin plate of platinum, and places the talc slip in the sphygmograph as if about to take a tracing of the pulse. He connects one terminal from a Leclanché's cell to the slip of platinum on the talc, and the second terminal from the cell to a terminal of the telephone. Then he connects the other terminal of the telephone with the metal rod of the sphygmograph which supports the talc. The instrument is now ready for use. It is placed on the pulse in the ordinary way, and is adjusted, with the writing needle thrown back, until a good pulsating movement of the needle is secured. When the movement is in full action, the needle is thrown over to touch the platinum plate, which it traverses with each pulse-movement and completes the connection between the telephone and the battery. The needle, in passing over the metallic plate, causes a distinct series of sounds from the telephone, which correspond with the movements of the pulse. When all is neatly adjusted, the sounds heard are three in number, one long sound and two short, corresponding to the systolic push, the arterial recoil, and the valvular check. The sounds are singular, as resembling the two words "bother it." The sounds can be made very loud by increasing the battery power. This little instrument is not so good a recorder of the pulse as the sphygmograph, but it may be made very useful in a class, for illustrating to a large number of students, at one time, the movements of the natural pulse, and the variations which occur in disease.

PHYSIOLOGY.

The Secretion of the Gastric Glands.—Professor Heidenhain succeeded in separating a considerable portion of the fundus of the stomach in a dog from its connection with the rest of the organ, and forming it into a blind sac communicating with the exterior of the body. This enabled him to collect the secretion of the gastric glands unmixed with that of the pyloric glands, and uncontaminated by the saliva and other liquids which pass down the œsophagus. The secretion is a clear, strongly acid liquid, containing an unexpectedly small amount of mucus, and an average of 0·45 per cent. of solid matter, partly organic, partly inorganic, the former consisting mainly of pepsine. The average acidity of the liquid is equivalent to 0·52 per cent. of hydrochloric acid, which is far higher than that of the mixed gastric juice, free from saliva, examined by Bidder and Schmidt. Richet, from observations on the juice of a man with a gastric fistula, found that when fresh it contained only hydrochloric acid, while when kept for a time it developed an organic acid, probably sarcolactic. No such acid was observed to be produced in the secretion obtained from the dog. It was found that the introduction of nutritious food into the stomach induced active secretion in from fifteen to thirty minutes, and this continued until the stomach had completely emptied itself. But if indigestible substances were introduced no secretion flowed from the sac for upwards of an hour. Water was then given to the animal, and secretion commenced, but only lasted an hour and a half. From these and other experiments, Professor Heidenhain concludes that mechanical stimulation of the stomach excites secretion only at the point of contact; general activity of the glandular apparatus requiring absorption for its production. If the composition of the secreted liquid be examined at regular intervals during the digestive process, its acidity is found to remain pretty uniform, but the proportion of pepsine contained in it undergoes a peculiar and orderly series of variations. During the second hour it sinks rapidly to a minimum; towards the fourth or fifth hour it rises again to a point generally higher than at first, and remains at or near this point for a considerable time. These variations are quite independent of the amount of pepsine actually contained in the glands which is known to sink steadily. The secreting surface can pour out a liquid very rich in pepsine at a time when its poverty in this substance is most strongly marked. No definite conclusion can at present be arrived at as to the cause of this phenomenon. (*Pflüger's Archiv.*, vol. xix.; *Academy*, April 26, 1878.)

ZOOLOGY.

The Bovidæ.—M. A. Sanson has communicated to the French Academy of Sciences a note on the results of his researches upon the fossil or ancient remains of Bovidæ and their relationships to existing forms, which are of some interest.

He finds that the Aurochs of Cuvier, *Bos urus* of Bojanus, *B. priscus*, Allen, *B. latifrons*, Harlan, and *B. antiquus*, Leidy, are all Bisons which

do not differ specifically from the existing *B. americanus* and *B. europæus*. They are at the utmost varieties of the same species.

Bos primigenius, Bojanus, is still represented by a numerous race, varieties of which occupy the ground between the *embouchures* of the Loire and Gironde, extending towards the south-east as far as Mont Aubrac. To this form M. Sanson gives the name of *Bos taurus ligeriensis*.

Bos trachoceras, Meyer, and *B. frontosus*, Nilsson, belong to a single species, M. Sanson's *B. taurus jurassicus*. This race, which is constantly extending, at present inhabits the cantons of Berne and Fribourg in Switzerland, and La Bresse and the valley of the Saône, is spreading more and more into the districts of Le Nièvre, Cher, and Allier in France, and is also disseminated in Germany, Austria, and Italy. It is one of the types found in the Lake-dwellings.

Bos longifrons, Owen, is an ancient representative of the existing *Bos taurus batavicus*. Its remains have never been found outside of the natural geographical area of the latter, included in the basin of the North Sea, and extending into England, Holland, Belgium, and the north of France and Germany. The craniological type of this race has most clearly defined characters, so that it is difficult to understand how it can ever have been confounded with that of *Bos primigenius*.

Bos brachyceras, Rütimeyer, survives in the *Braunvieh* of Switzerland, named by M. Sanson *Bos taurus alpinus*, as it inhabits the region of the Alps, where it has formed numerous varieties.

Bos brachycephalus, Wilcken, remains of which are found in the peat of Laibach, is supposed by its describer to be derived from the European Bison. It is identified by him with a race existing in Tyrol, which was formerly regarded as a hybrid of *Bos frontosus* and *B. brachyceras*. This is regarded by M. Sanson as its most probable origin.

Sulphuret of Carbon for Killing Insects.—Dr. J. M. Eder proposes the use of a sulphuret of carbon bottle for killing insects in place of the cyanide of potassium bottle which is now so commonly employed. He describes it as particularly well adapted for beetles. The apparatus recommended is a wide-mouthed bottle, well-corked, containing a few fragments of blotting-paper. When an insect is captured and put into the bottle it is to be followed by three or four drops of sulphuret of carbon (a supply of which must be carried in a small store-bottle), when the animal is almost instantaneously killed by the action of the vapour produced. The largest beetles die in a few seconds. With careful corking after the introduction of each capture, the three or four drops of sulphuret of carbon will continue their action for an hour or two, but as soon as the insects begin to die slowly, a fresh supply of the reagent must be added. The great advantage is that owing to the rapidity with which sulphuret of carbon evaporates, the interior of the vessel is always perfectly dry, so that no insect, however delicate, can be injured by it. Solution of cyanide of potassium is said to beslower in its action, and to have the disadvantage of introducing moisture, and of giving origin to carbonate of potash, a hygroscopic salt.—(*Verhandl. Zool. bot. Gesellsch. in Wien*, 1878.)

Sounds produced by Fishes.—M. W. Sörensen, during a residence at the mouth of the Riacho del Oro (Paraguay), had the opportunity of investigat-

ing the mode in which certain fishes of the rivers in that region, especially Siluroids and Characini, are enabled to emit sounds. The organ implicated in this phenomenon is, according to him, the air-bladder, which is peculiarly modified. In the Siluroids, the unossified part of the air-bladder is elastic throughout, whilst in the Characini the elasticity chiefly depends upon flat bands or round cords situated in the wall. In the Siluroid genera *Platystoma* and *Pseudaroides*, the air-bladder is divided by a longitudinal partition and by several transverse ones into a number of chambers which, however, still communicate with each other. In *Doras*, it has numerous appendages divided by imperfect septa into a great many small cells. In all these fishes the transverse processes of the two or three first vertebræ, and often a part of the arch of the first vertebra, are bound together and to the hinder part of the skull by strong elastic membranes. The transverse processes of the first or second vertebræ, and sometimes of both, are formed into powerful springs and closely bound to the air-bladder. The sound is produced by the action of muscles inserted, either directly upon the air-bladder, or upon the transverse process of the third vertebra. In the Characini, the elastic parts of the air-bladder are stretched lengthwise by the contraction of the muscles, and the vibration produced by this movement is transmitted to the air contained in the cavity of the bladder. In the Siluroids the forepart of the air-bladder is drawn alternately forward and backward by the contraction and relaxation of the muscles, and the air passing by the imperfect transverse partitions sets these in motion and causes the sounds.—(*Comptes rendus*, May 19, 1879.)

Trichinæ in the Hippopotamus.—M. E. Heckel announces the occurrence of *Trichinæ* in great abundance in a young hippopotamus received from Egypt, which lived for about four months in the Zoological Gardens at Marseilles. The animal suffered from skin disease, taking the form of great suppurating boils, during the whole of its residence at Marseilles. On examination these sores were found to have penetrated the skin, and to lead to great cysts filled with pus in the subcutaneous tissue. It was after the greater part of the flesh had been thrown away that M. Heckel detected the *Trichinæ* in the muscles surrounding one of the cysts which he had kept, and he was unable to ascertain whether the trichinosis and the external symptoms were in any way correlated. The discovery of the parasite in this great Pachyderm is of interest.—(*Comptes rendus*, June 2, 1879.)

Metamorphoses of the Blister-Beetles.—The transformations of the common blister-beetle, or so-called Spanish fly of the shops (*Lytta vesicatoria*) have eluded the researches of entomologists, although the insect itself is exceedingly abundant on ashes and other trees in the south of Europe. The life-history of other species of the same family (*Meloë*, *Sitaris*, *Epicauta*) has, however, been worked out, and entomologists will be glad to learn that M. Lichtenstein, guided by the results obtained in the investigation of those forms, has at last succeeded in solving the problem and demonstrating that the stages through which the officinal blister-beetle passes are very similar to those presented by its nearest relatives.

At the end of May, or the beginning of June, the females deposit their eggs in small excavations in the ground; the eggs are elongated, whitish, and transparent, and each female lays several hundred of them in a small

mass. They hatch in a fortnight, and the larva produced is, as in the case of the other genera, a "Triungulinus," a little, active, three-clawed creature, originally detected upon bees, and described as a special parasite, before its connection with these beetles was known. The Triungulinus of the blister-beetle is dark brown, with a white band across the middle of its body; its eyes are black and prominent, and its jaws very sharp, and it has two long caudal bristles. M. Lichtenstein had some difficulty in getting the young animals to feed, but at last he tempted them with the stomachs of honey-bees, and then gave them the eggs and young larvæ of various species of bees. But he found that it was necessary to associate honey with their animal food, otherwise they would not touch the latter, almost as if they were instinctively aware that honey would be absolutely requisite for their sustenance as soon as they had undergone their first change of skin. When this condition is fulfilled, however, he found that they at once inserted their jaws into the egg or larva before them, and increased rapidly in size. In five or six days they changed their skin, and gave origin to small, white, six-footed larvæ, without caudal bristles, and with blunt jaws; these quitted the animal food and devoted themselves to the honey. In five days more there was another change of skin; after which the jaws were still broader and the eyes less marked; and after the next change, which took place five days later, the eyes had disappeared, the legs and jaws had become brown and horny at the end, and the larva had the appearance of a small grub of a Lamellicorn beetle. This form is called by Mr. Riley the "Scarabæoid larva," and it was apparently fitted for burrowing. . Accordingly the insects in this stage were transferred to a new form of prison, in which they had a sufficient quantity of damp earth in which to bury themselves, which they proceeded to do at once, making their way nearly to the bottom of the earth in their tubes, and resting in a small cavity close to the wall of the tube, thus enabling the author to observe their subsequent proceedings. After remaining here for another five days they underwent a fresh change, and gave origin to a pupa-like creature, having four little tubercles at the anterior end, and three pairs of tubercles at the points where the legs had been situated. In this state they remained motionless through the winter, but on April 15 they burst their envelope, and produced, not a perfect beetle, but a white, grub-like creature, with rudimentary feet, and in other respects somewhat resembling the larva which had burrowed down into the ground. In this condition the insect moved slowly in its cell, but ate nothing, until in about a fortnight, it again cast its skin and gave birth to a pupa, presenting all the characters of those of beetles. At first white, the pupa speedily became coloured; on May 17 it was quite of a dark tint, and on the 19th the perfect beetle was seen in its retreat ready to emerge. The development had thus occupied just a year. M. Lichtenstein believes that the burrowing bees, such as the *Halicti* and *Andrenæ*, are those at whose expense the blister-beetle is nourished.—(*Comptes rendus*, May 26, 1879.)

The Gall-Aphides of the Elm.—Dr. Riley has ascertained that the natural history of the aphides which produce galls deforming the leaves of the common American Elm is exceedingly complicated. The species described by him is *Schizoneura americana*. During the winter, in the cracks in the bark of an elm, the leaves of which suffered much from the attacks of the

aphides the preceding summer, the eggs may be found, often still covered by the dried skin of the mother. The eggs are of a dull-yellow colour, and about $\frac{1}{50}$ inch long. Early in the spring these eggs give birth to a little crawling insect which proceeds to attack the young tender leaves, on which it feeds, causing the leaf to pucker until it at last curls into a protective shelter for the so-called "stem-mother." After three months the latter begin to people the leaf with viviparously produced young at the rate of about one every six or seven hours. The second generation resemble their parent in many respects, but none grow so large; they accumulate in immense numbers, and some of them, crawling away, form new colonies on other leaves. They produce the third generation, which is destined to acquire wings, and the individuals forming it, which are short-lived, deposit twelve or more "pseudova" at intervals of about half-an-hour. The young aphides, issuing from these, and constituting the fourth generation, are very active and move swiftly. They are of a brown colour, and in general appearance somewhat like those of the second generation. In this stage they swarm over every part of the tree, and their necessities often cause them to migrate, during which process great quantities of them are destroyed. The fifth generation is very similar to the fourth, but without wings. The aphides of the sixth generation all acquire wings. They abound in the latter end of June and the early part of July. They congregate on the bark, seeking out sheltered cracks and crevices in which they deposit their young, forming the seventh generation, which are sluggish and of the colour of the bark, the females being a little larger than the males. They have no mouth, but live motionless for a few days, during which the female seems to increase in size by the enlargement of her single egg. Both sexes soon perish, leaving among their shrivelled bodies the shining, brownish winter-egg from which this series of generations started; so that, as Dr. Riley says, after a long series of vegetative (agamic) reproductions, at last the time comes for the renewing of the race by this zygospore-like body.—(*Journ. Roy. Micr. Soc.*, June, 1879.)

A Supposed New Order of Crustacea.—In the February number of the *American Naturalist*, Dr. A. S. Packard, jun., observes that the *Nebaliadæ*, represented by the existing genus Nebalia, have generally been considered to form a family of the Phyllopod Crustacea; Metschnikoff, who studied the embryology of *Nebalia*, considering it to be a "Phyllopodiform Decapod." But besides the resemblance to the Decapods there is also a combination of Copepod and Phyllopod characteristics. The type, he points out, is an instance of a synthetic one, and is of high antiquity, having been ushered in during the earliest Silurian period, when there were (if we regard the relative size of most Crustacea, and especially of the living *Nebaliæ*) gigantic forms. Such was *Dithyrocaris*, which must have been over a foot long, the carapace being seven inches long. The modern Nebalia is small, about half-an-inch in length, with the body compressed, the carapace bivalved, as in *Limnadia*, one of the genuine Phyllopods. There is a large rostrum overhanging the head; stalked eyes, and besides two pairs of antennæ and mouth-parts, eight pairs of leaf-like, short, respiratory feet, which are succeeded by swimming feet. There is no metamorphosis, development being direct.

Of the fossil forms, *Hymenocaris* was regarded by Salter as "the more generalized type." The genera *Peltocaris* and *Discinocaris* characterize the lower Silurian period, *Ceratiocaris* of the upper, *Dictyocaris* the upper Silurian and the lowest Devonian strata, *Dithyrocaris* and *Argas* the Carboniferous period. Our existing north-eastern species is *Nebalia bipes* (Fabr.), which occurs from Maine to Greenland.

The Nebaliads were the forerunners of the Decapoda, and form, Dr. Packard believes, the type of a distinct order of Crustacea, for which he proposes the name of Phyllocarida.

A Segmental Organ in the Endoproct Bryozoa.—In the *Comptes Rendus* of February 24, 1869, M. L. Joliet brings forward evidence in support of the observations of Hatschek, who, in October 1877, indicated in *Pedicellina echinata*, both in the larval and adult state, a vibratile canal, of which, however, he did not appear to have well made out the form, and which he compared to the vibratile organs of the Rotatoria. M. Joliet states that he is now in a position to confirm, correct, and complete the statements of Hatschek, and to extend them to the whole group of Endoproct Bryozoa.

In a spineless variety of *Pedicellina echinata* which he examined, the vibratile organ was double, and situated in the cavity of the body, in the space included between the œsophagus, the stomach, and the matrix. It consisted of a short tube, ciliated internally, inflated at its middle, which, on the one hand, opened into the matrix, not far from its external aperture, and, on the other, opened obliquely into the cavity of the body by a slightly funnel-shaped passage furnished with active vibratile cilia. This organ, furnished with a vibratile pavilion, and placing the cavity of the body in communication with the outer world, had all the characters of a segmental organ. It appears very early in the bud; and when the stomach is only sketched out, and before the arms are indicated, a ciliary movement is already perceptible at the place that it will occupy.

In a still undescribed species of *Pedicellina* from the island of St. Paul, M. Joliet has also detected the same vibratile organ; and still later, in the *Loxosoma* of *Phascolosoma*, he recognized a perfectly similar canal, terminated by a pavilion and placed in the same situation. As in *Pedicellina*, it appears very early in the bud.

M. Joliet therefore concludes that in the group Endoprocta, including the highest forms of the Bryozoa, the presence of a segmental organ (that is to say, an organ which is very generally diffused among the Vermes) may be regarded as constant; and considering the endeavours that have been made of late years to approximate the Bryozoa to the Annulata, he thought it an advantage to bring this new argument into the debate, as possessing considerable value.

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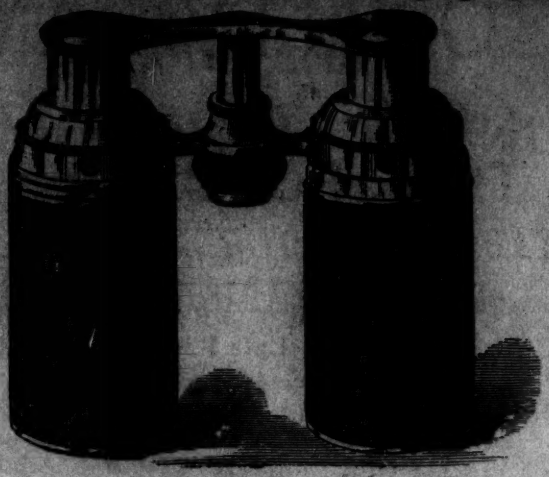

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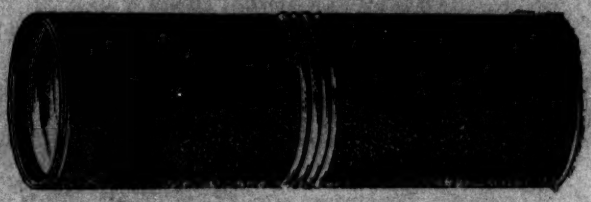

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